CALIFORNIA ENERGY COMMISSION

Renewable Transmission Planning Workshop

September 14, 2004

Project Organization

California Energy Commission PIER Program:

- Program Area Lead – George Simons
- Project Manager – Prab Sethi

Project Organization

Project Consultants:

- Ron Davis - Davis Power Consultants – Lead
- Kollin Patten - PowerWorld Corporation
- Tony Visnesky - Anthony Engineering

- DPC referenced in presentation corresponds to the entire consulting team.

Agenda

This workshop is organized in five sections:

A. Introduction - Strategic Value Analysis Project
    A. Objectives
    B. Organization
    C. Model Selection
B. Applications of the Model
    A. Renewable Site Examples
        A. Geothermal
        B. Wind
    B. Transmission Planning using Weak Element Ranking
    C. Policy Analysis using Penetration-Reliability Curves.

Agenda Cont'd

C. Determination of Weak Elements (Hot Spots)
   A. Contingency Analysis
   B. Weak Element Identifications and Visualization Results
D. Spatial Representation of Beneficial Sites
   A. Sensitivity Analysis (transmission loading relief)
   B. Location ranking based on reliability benefit
   C. Results
E. Conclusions

Purpose of SVA Study

- Originally intended to help target renewable energy research
  - Performance, costs and locations of renewables
  - Focused on renewable DG applications at distribution levels
  - Only went out to 2007
- SVA expanded and extended after RPS enacted
  - Included bulk renewables and transmission levels
  - Extended out to 2017

Approach

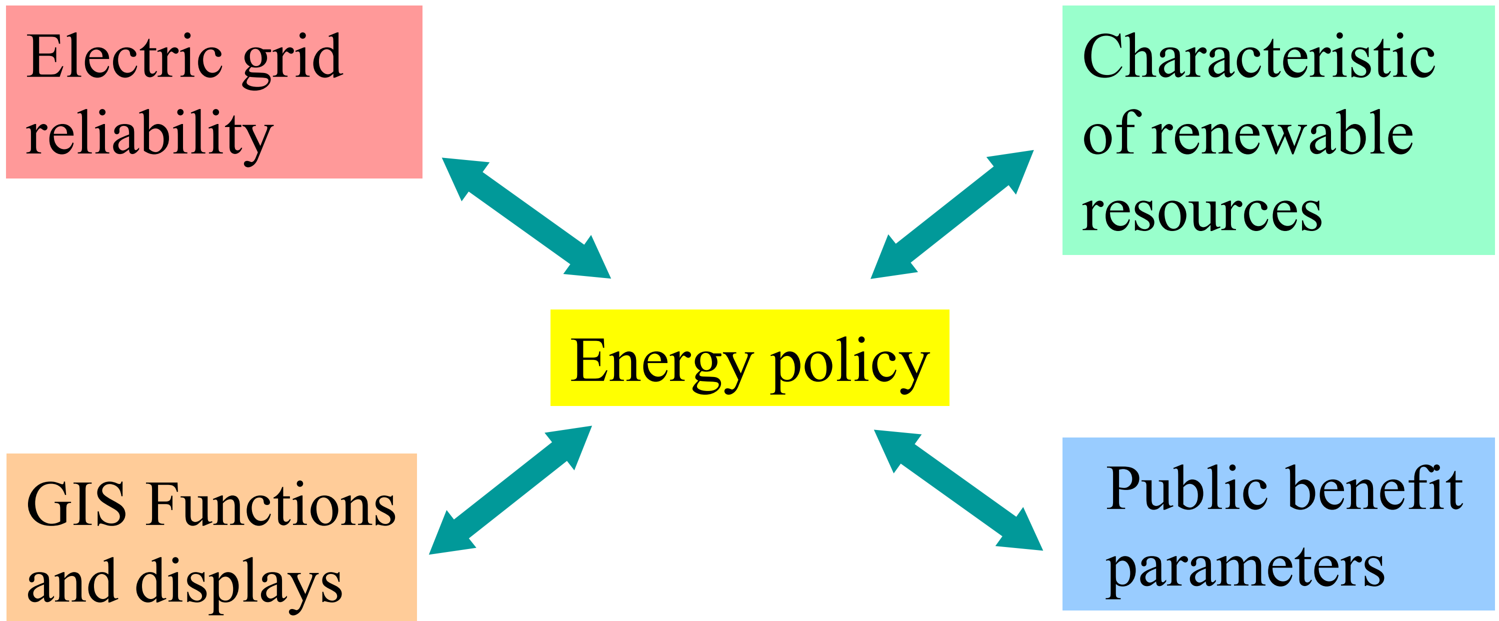
- Identify links between electricity needs in the future with available renewable resources
- Optimize development and deployment of renewables based on their abilities to provide benefits to:
  - Electricity system
  - Environment
  - Local economies
- Target research needed to help achieve goals

Five Step Methodology

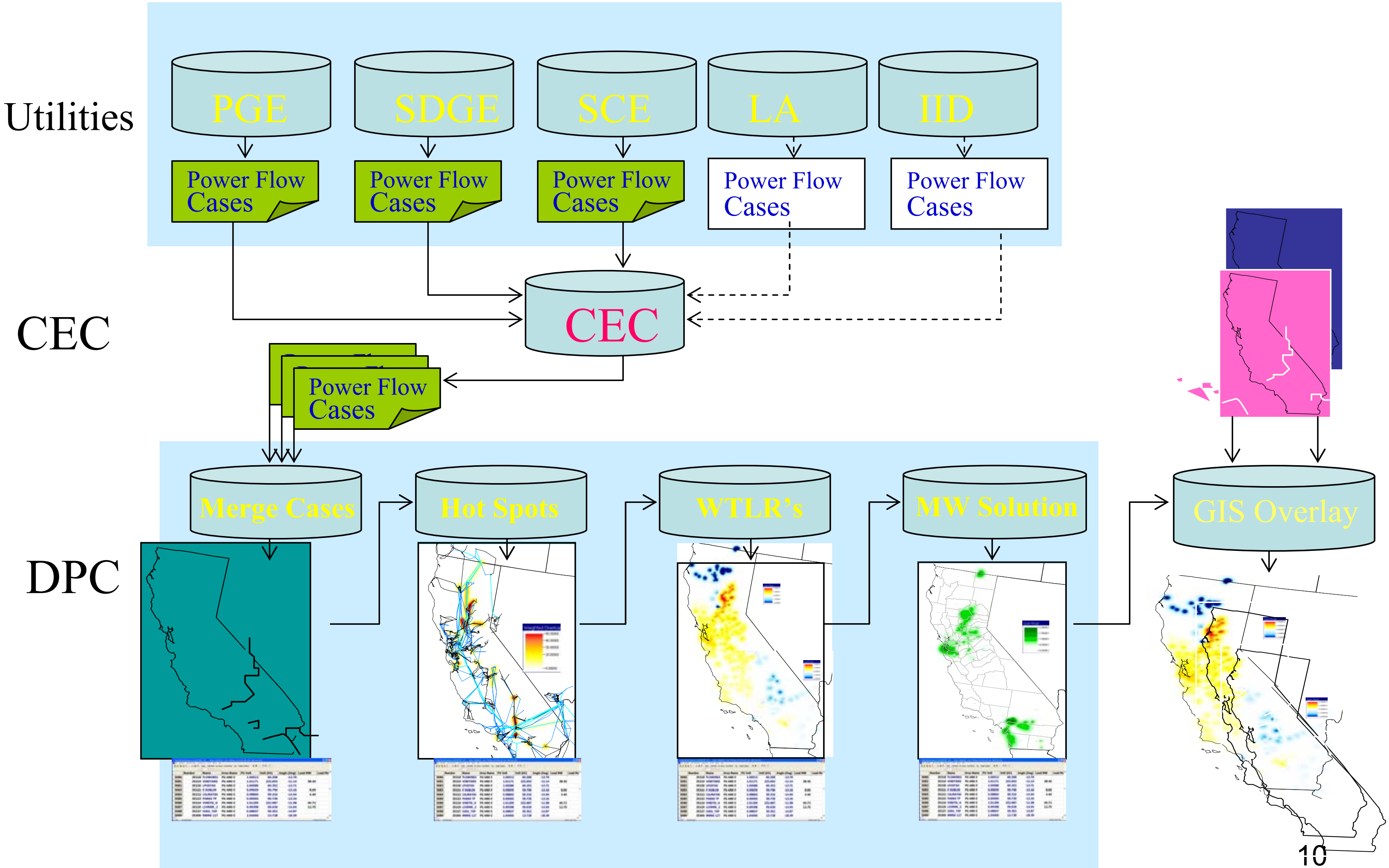
- Identify, quantify and map electricity system needs out through 2017 (capacity, reliability, transmission)
  - Selected years (2003, 2005, 2007, 2010 & 2017)
- Identify and map out renewable resources
  - Wind, geothermal, solar, biomass and water (hydro & ocean)
- Project environmental, cost and generation performance of renewable technologies through 2017
  - Projections developed by PIER Renewable staff; corroborated by work done by EPRI, NREL and Navigant
- Conduct combined GIS and economic analyses to obtain "best-fit, least-cost" approach
- Develop RD&D targets that help drive forward renewables capable of achieving identified benefits

Project Overview

- Project has several interrelated components



Visual Depiction of Methodology



Basic Models Needed

- Transmission Power Flow Modeling
- Economic Models
- GIS Analysis and Mapping Capability (California Department of Forestry)

Simulation Process

- Conduct transmission load flow analysis (steady state and first contingency) 6,000 case for CA
- Determine potential location of transmission overloads, congestion and low voltage based on contingencies
- Determine amount of generation injection and location to reduce or eliminate transmission problems
- Overlay renewable technology locations to find optimal location for development

Transmission Modeling Requirements

- Interactive – Easy to use; able to be used by non-engineers
- Portable – PC based for wide use
- Accurate, capable of handling small and large systems (WECC, PJM, etc.)
- Affordable
- Expandable – must be programmable to incorporate the new features into the model

Transmission Modeling Tool

- DPC selected the transmission power flow model named “PowerWorld Simulator”.
- Model has been enhanced to automate the entire process:
  - Power flow analysis
  - Contingency analysis
  - Determination of weak elements
  - Finding location of problem areas
  - Determining viable MW solutions
  - Output files for GIS overlays

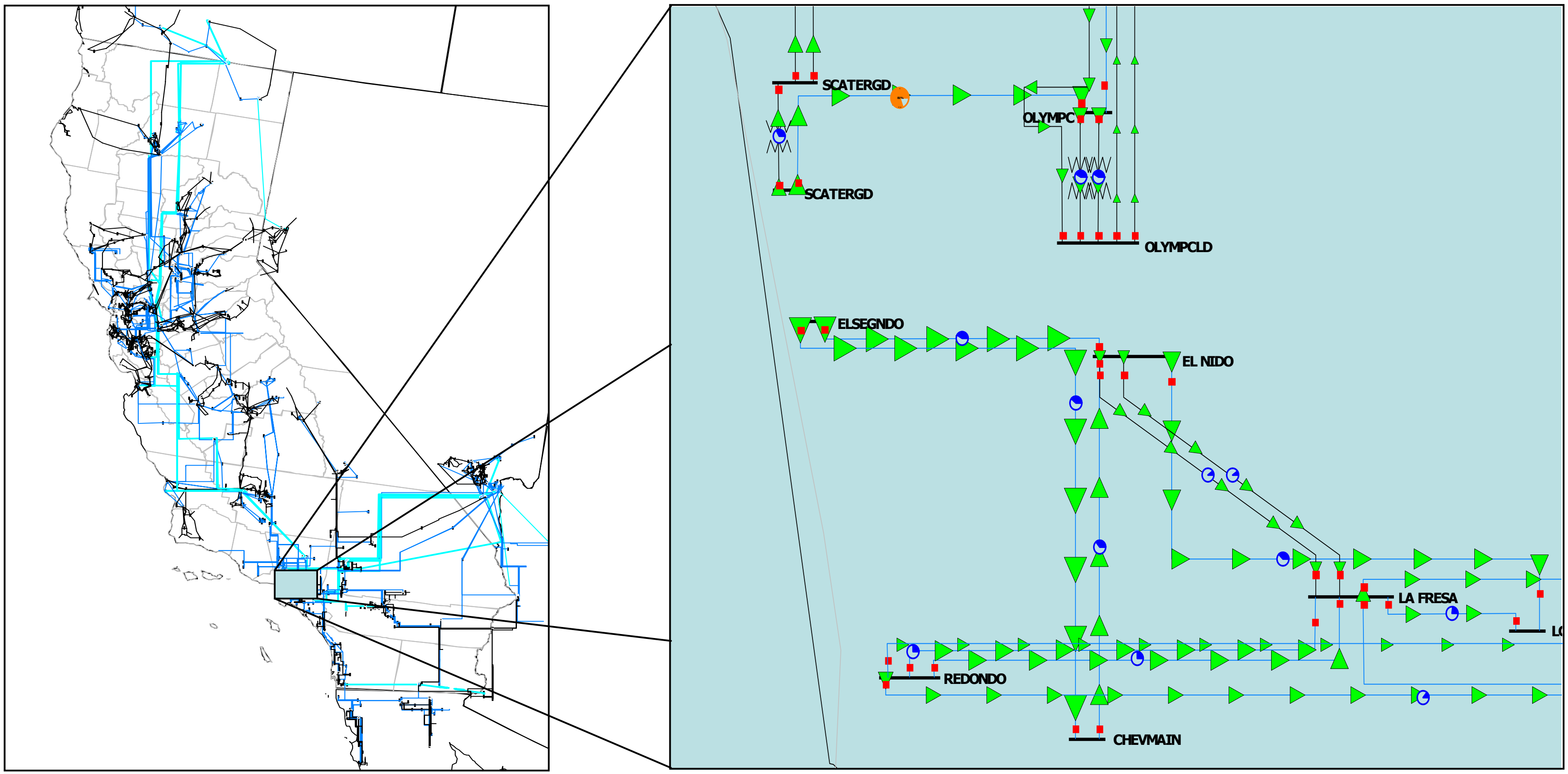
PowerWorld Simulator

- User-friendly and highly interactive power system analysis and visualization platform
- Single integrated environment with many available steady state load flow tools
  - Contingency Analysis: supports complex conditional actions and RAS modeling
  - Voltage Stability (PV: “nose curve”, QV: reactive power margin)
  - Optimal Power Flow (standard and security-constrained)
  - Transfer Capability
  - Power Transfer Distribution Factors
  - Transmission Loading Relief Factors
  - Line Outage Distribution Factors

PowerWorld Customers

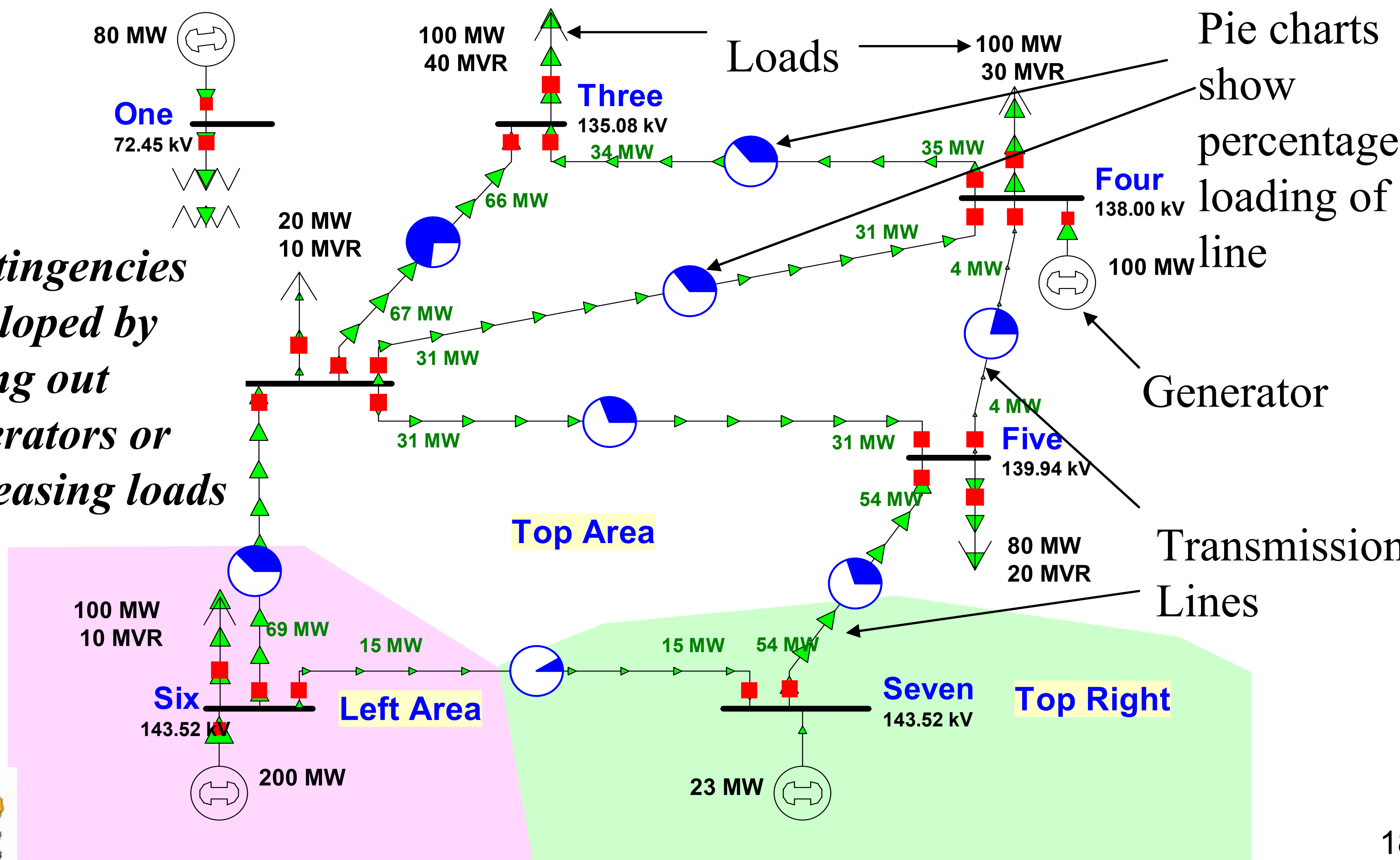
Over 350 customers world-wide, including:

Electronic Diagrams



Power Flow Simulations: Simplified Example

Contingencies developed by taking out generators or increasing loads

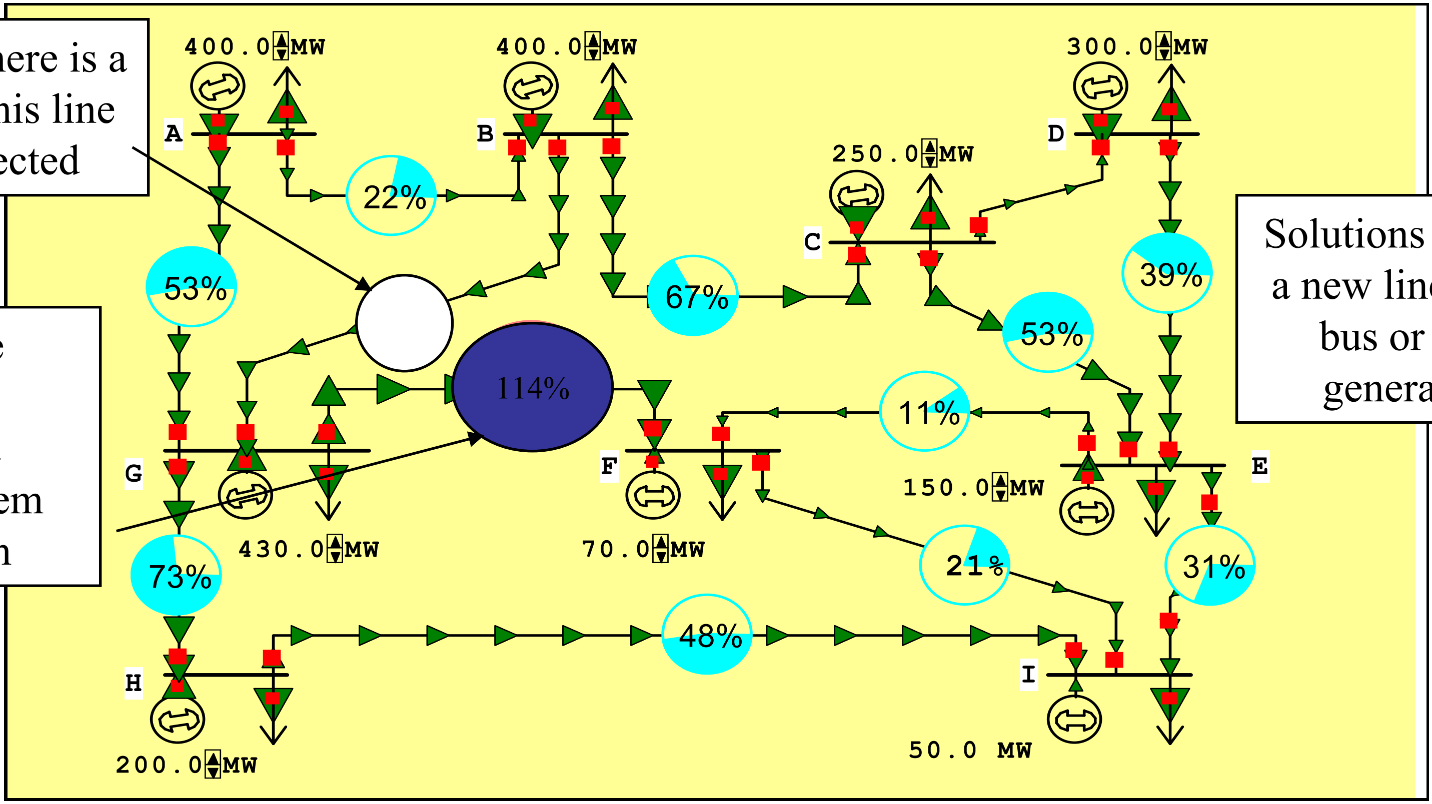


Power Flow Simulations: Contingency Example

Suppose there is a fault and this line is disconnected

Then this line becomes overloaded; a serious problem for the system

Solutions include a new line to the bus or new generation



Economic Parameters

- Standard financing parameters applied to each renewable technology
  - Debt/equity ratios and costs
  - Discount rate
  - Financing term
  - Depreciation
  - Property Tax, Insurance, Legal, and Administrative Rates as a percentage of book value

Levelized Cost of Energy (LCOE)

Generation LCOE

- Standardized LCOE by technology and year from CEC[1]

+

Transmission LCOE

- Estimation of specific interconnection requirements of each project
- Financial parameters consistent with those applied to the generation

=

Total LCOE

Public Benefits

- Refining technical potential to incorporate environmental and social aspects
  – Reduce wildfires, pollution, emissions, etc.
  – Increase employment, safety, customer choice, resource diversification, etc.

Overall System Solutions

- Overlay renewable technical potential in problem areas
- Develop renewable economic potential
- Complete economic comparisons
  - T&D
  - Conventional generation
  - Renewables
- Compare environmental benefits associated with developing renewables
  - Reduce wildfires, pollution, emissions, etc.
  - Increase employment, customer choice, resource diversification, etc.

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Renewable Transmission Planning Workshop

Renewable Technology Applications of the Model

Examples of Applying the Strategic Value Analysis to Wind and Geothermal

Mapping CA's Renewable Resources

- Identify the types and amounts of renewables that can help resolve "hot spots"
- Existing data old, inaccurate and not readily useful
  - Based on 1980 or earlier information
  - Lacked geographical precision and coverage
  - Not transferable to GIS
- New resource assessments developed with updated information and in GIS format
  - Wind
  - Geothermal
  - Biomass
  - Solar
  - Hydro

Transmission Power Flow Evaluation

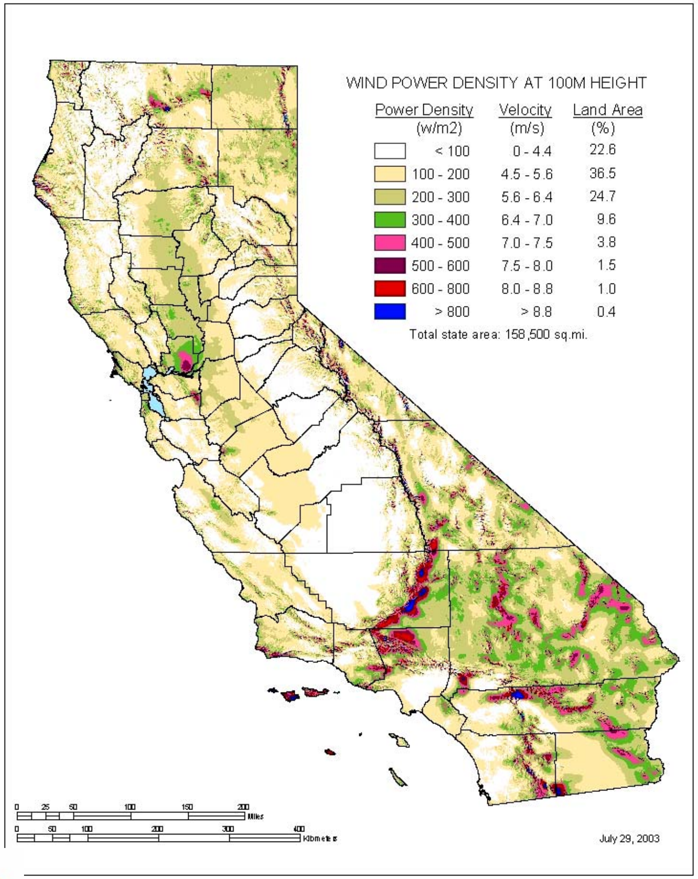
- Determine resource penetration for selected years
  - Existing system until overload occurs
    - Calculate a Impact ratio (MW benefit/MW installed)
  - New transmission line/substation until overload occurs
    - Calculate a Impact ratio (MW benefit/MW installed)
- Determine timing to install transmission and power plants, adjust transmission plan
- Separate resources into installation periods such as 1-3 years, 4-9 years, over ten years
- Prioritize resources within each time period

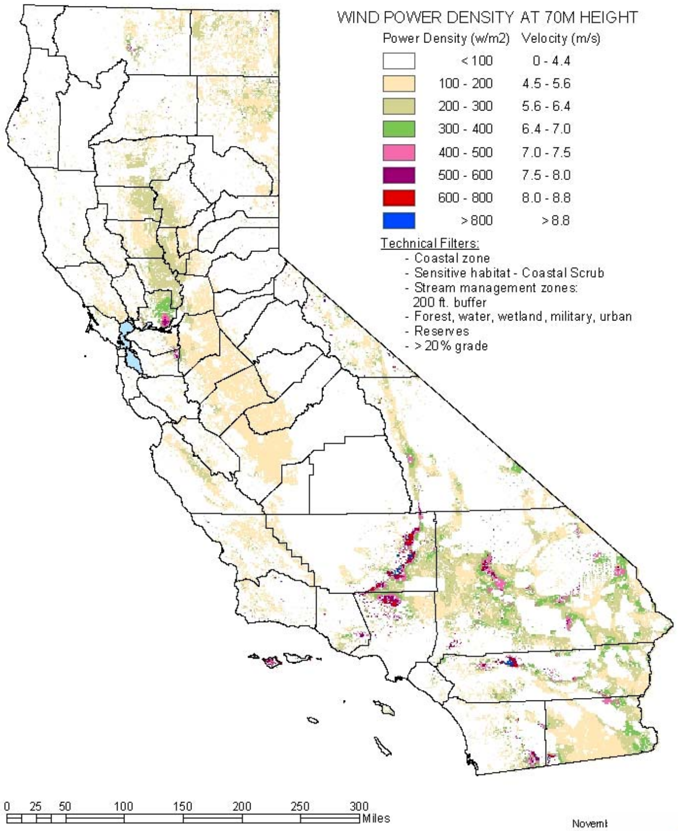
Potential Wind Sites

Development of New CA Wind Resource Assessment

- Developed by TrueWind in 2002
  - Based on a predictive model (MesoMap) that is “fitted” for accuracy using monitored data
  - Provides wind speed and wind power data at four wind turbine heights (30m, 50m, 70m and 100m)
  - Data specified on 200x200 meter grids; providing over a billion points of wind data for the state
  - Geographically specific and GIS compatible
- Same approach used by NREL

Visual Comparison of Gross Vs Technical Wind Potentials

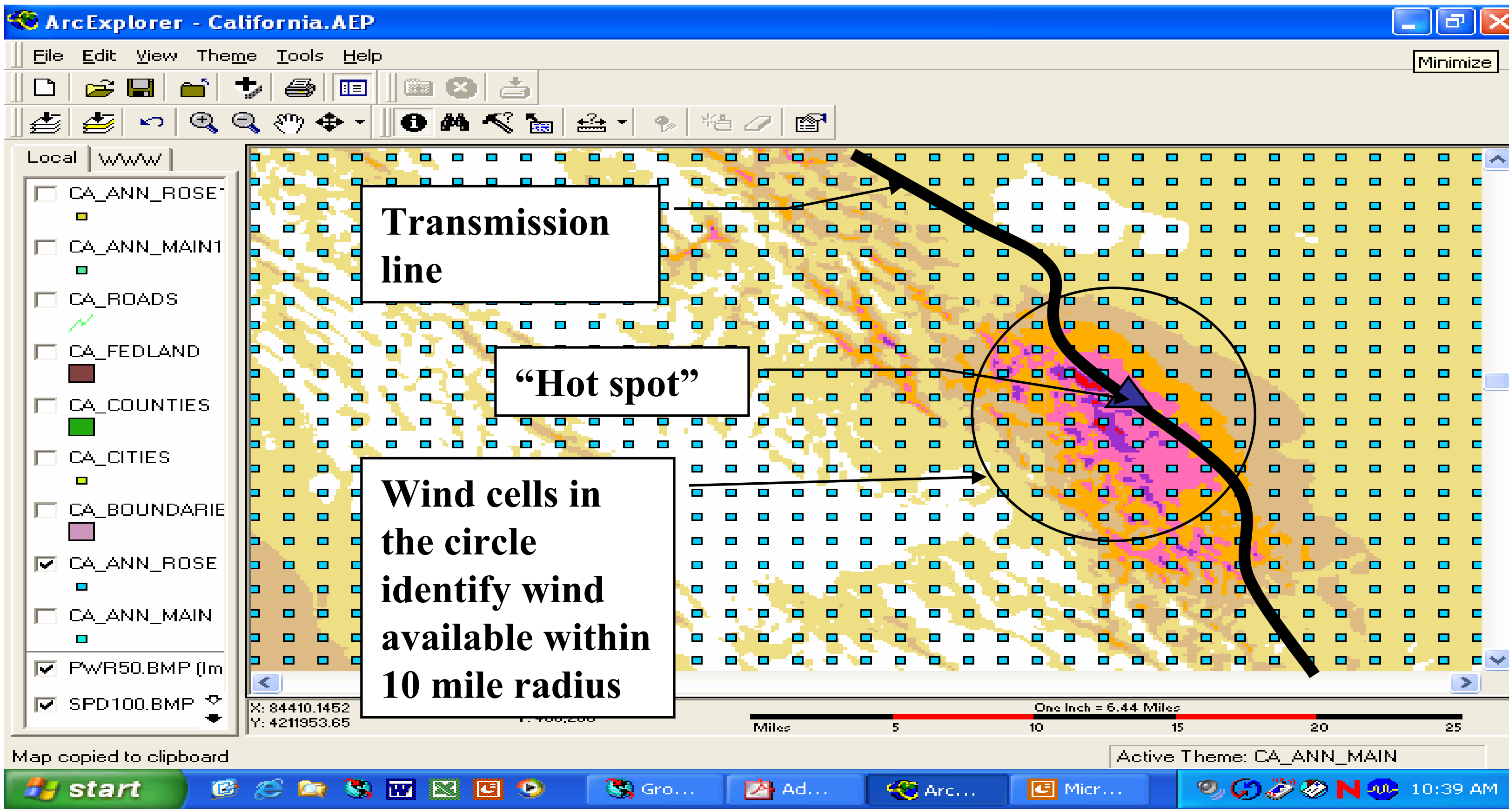




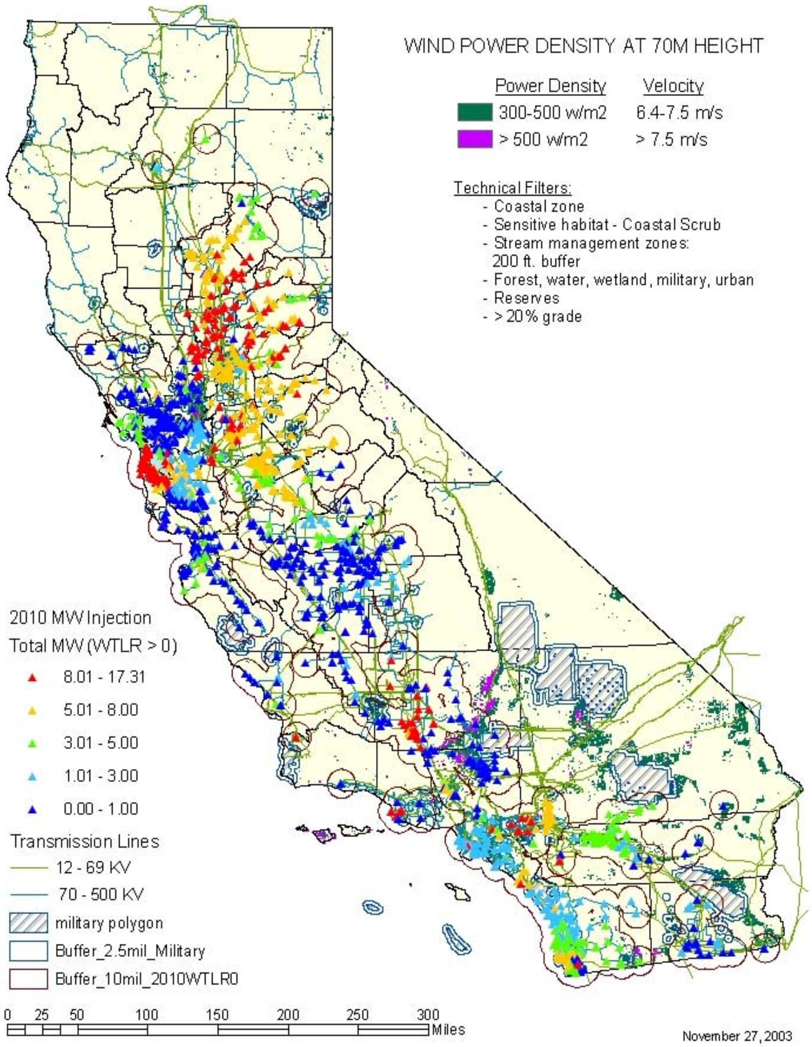
Mapping Renewables to Hot Spots

- Electricity Analysis
  - Identifies “hot spots” and magnitude of problem
    - WTLR indicates extent to which solution helps the overall system
    - MW solution quantifies and places the solutions on a geographically precise basis
      - Important in obtaining realistic estimates of solutions and costs
- Mapping Renewables to Hot Spots
  - Assesses if sufficient renewables are located in proximity to “hot spots”
    - Enables transmission upgrades and costs to be identified

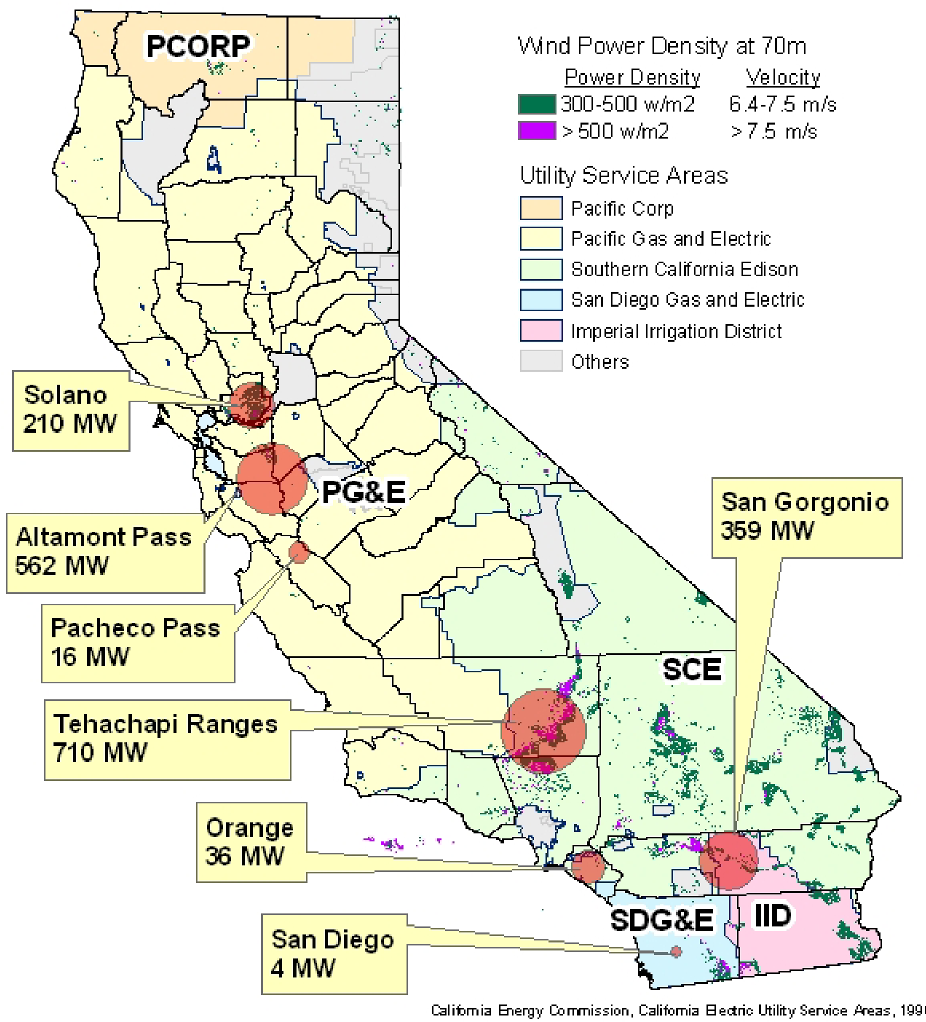
Simplified Example of Mapping Wind Resources to Hot Spots



Visual Example of Statewide Mapping of Wind to Hot Spots for 2010

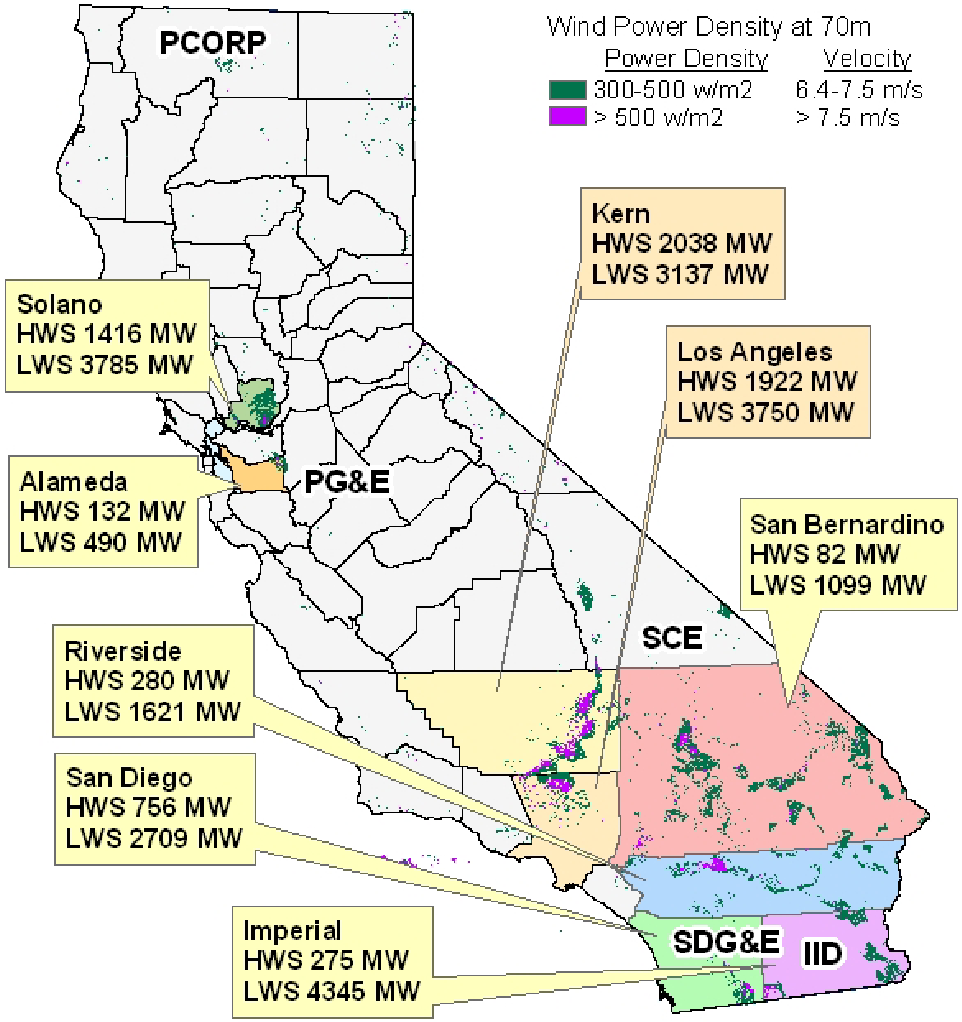


California's Existing Wind Developments



Shows CA's ~1900 MW of existing wind capacity circa 2003

CA Wind Potential
High and Low Wind Speeds

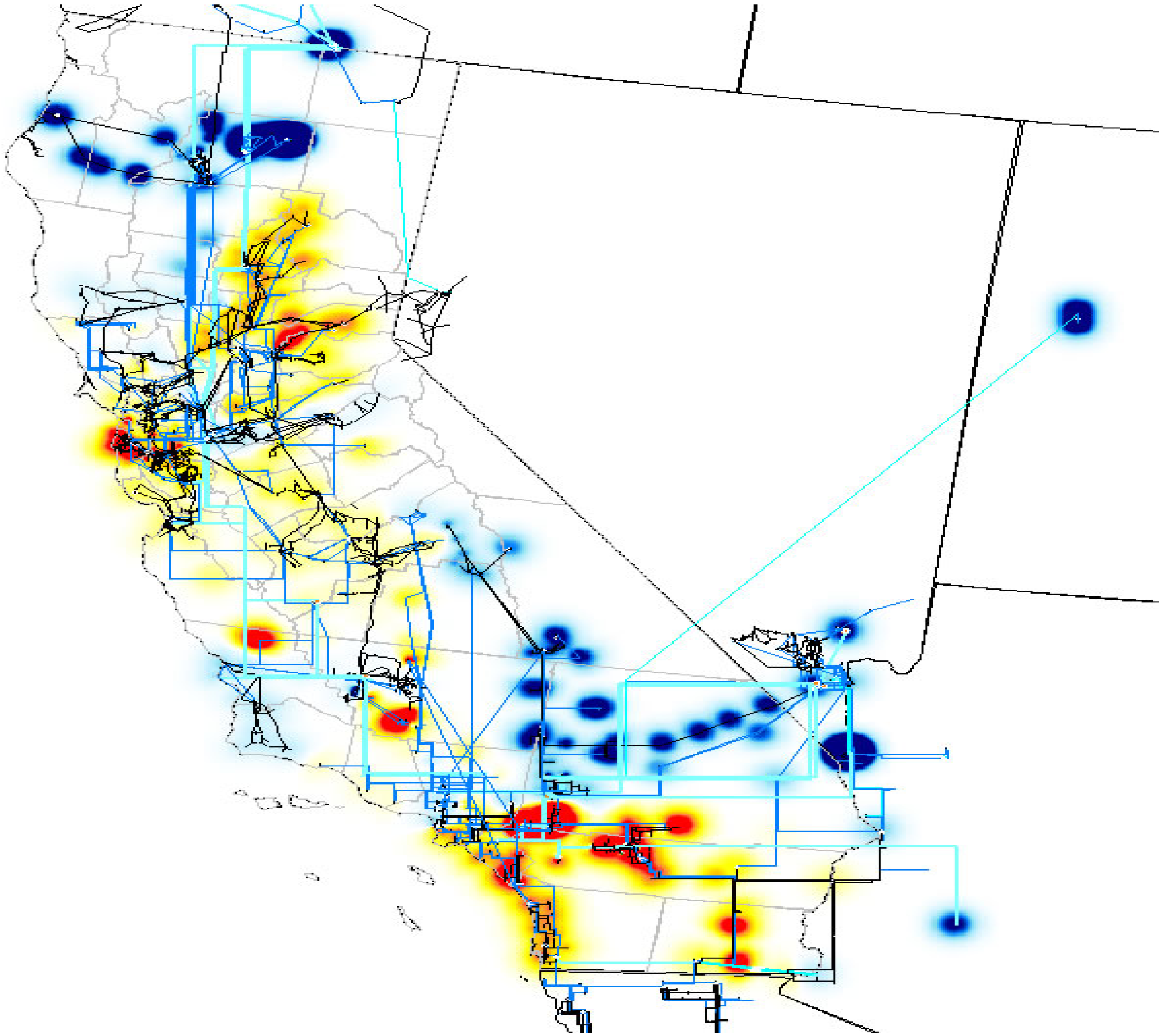


Potential before looking at the feasibility and economics of connecting to the grid

Selection of Wind Sites

- Determine wind technical potential
- Prepare GIS maps of the locations
- Overlay the transmission hot spots
- Select sites for solution analysis
- Calculate the benefit ratio
- ETWC – Effective Transmission Wind Capacity
  - Amount of wind generation that could be exported over the transmission grid at summer peak

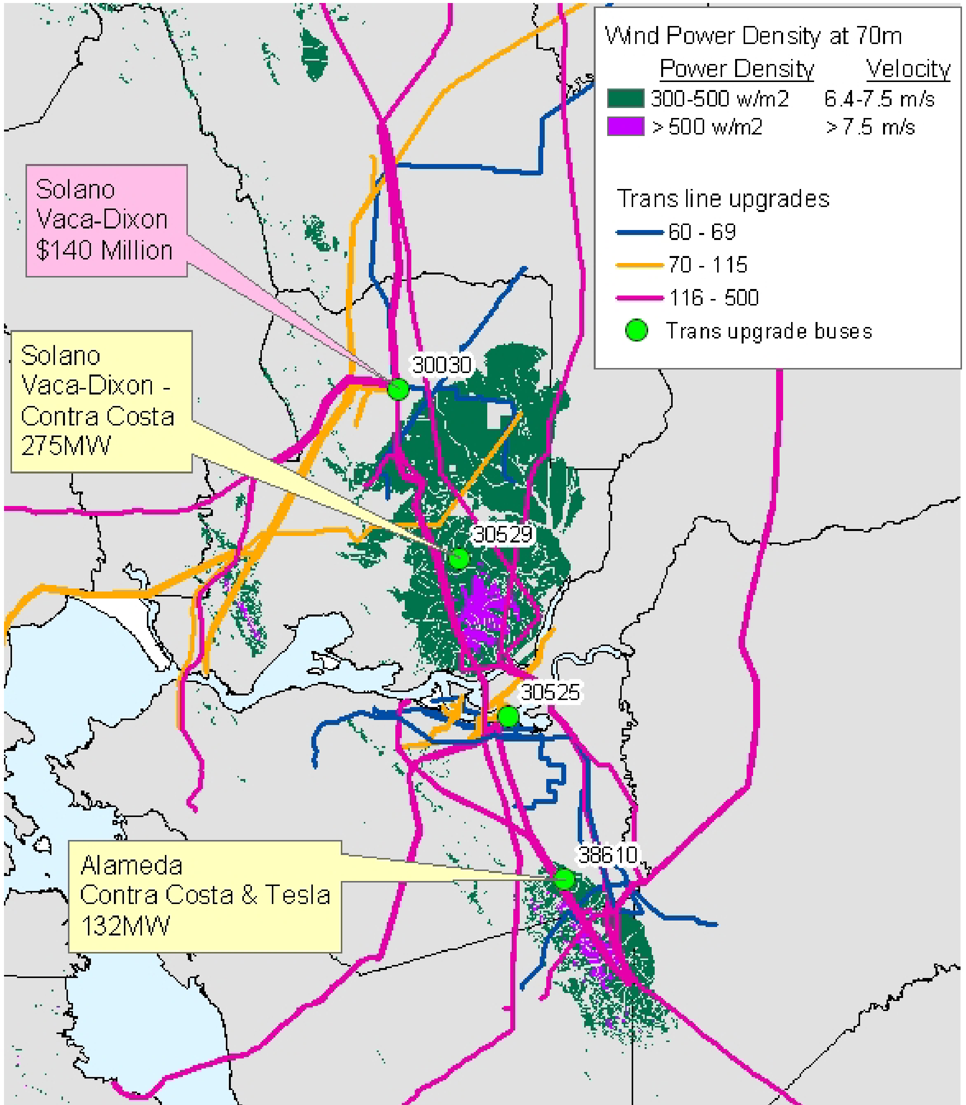
2010 Hot Spot –Base Case



Solano County Wind Site

- Technical Potential   275 MW
- Located at southeastern corner of county
- Connected to HIWD Tap (30529) by new substation
- Tap is connected to Vaca-Dixon and Contra Costa substations by 230 kV line
- No impact to existing system

Detail on Solano Wind Developments



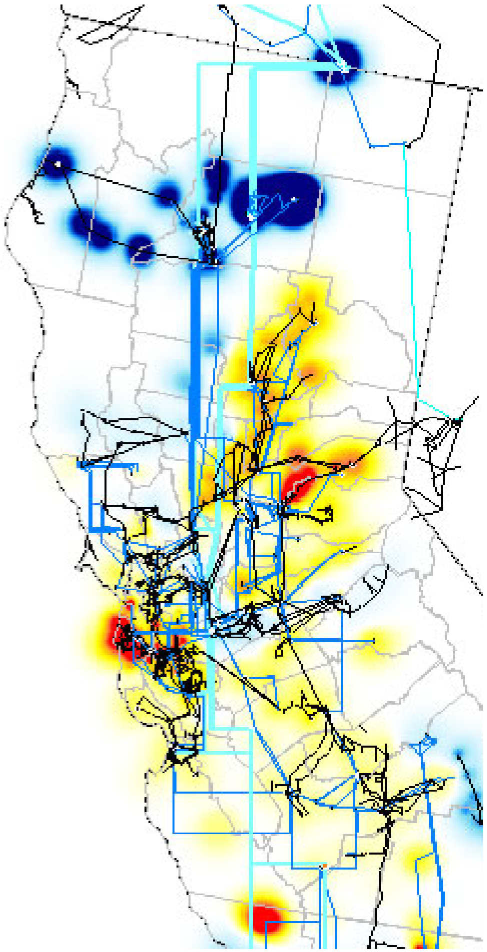
Projected AMWCO

• ETWC	165 MW
• AMWCO Impact	-111 MW
• Impact Ratio	-0.67

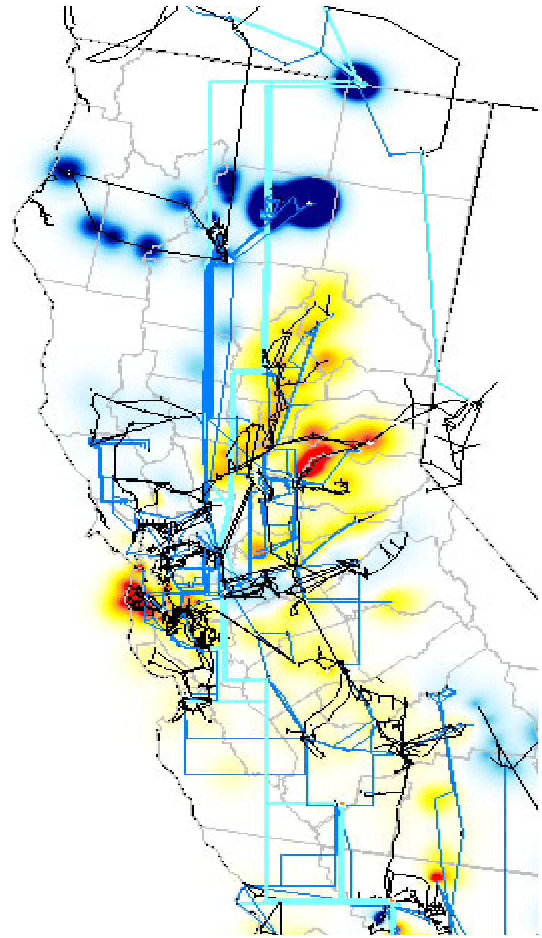
- PG&E renewable concept plan supports the installation up to 175 MW. Above this, a second 230 kV line from Vaca-Dixon to Contra Costa is needed

Solano County After Map

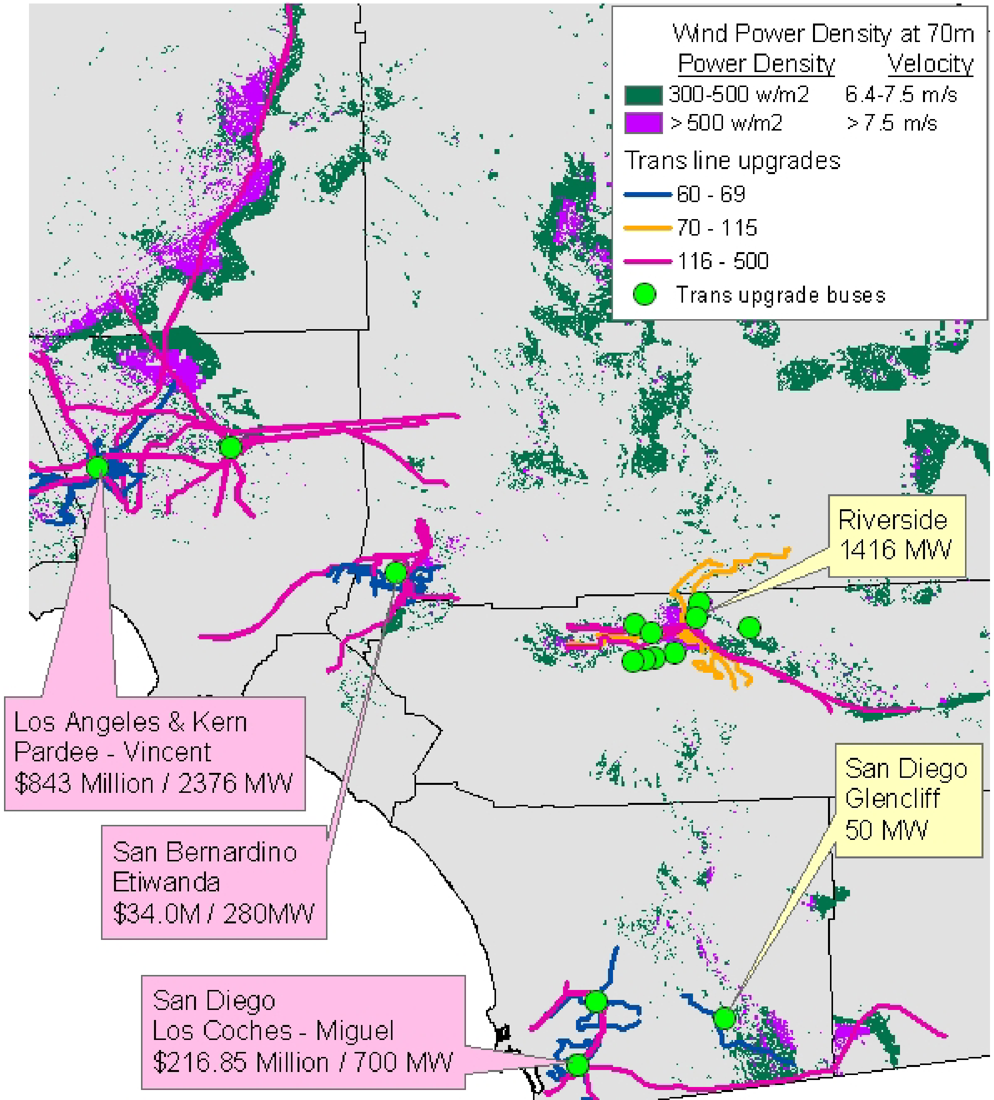
Before



After



Detail on Southern CA Wind Developments



Riverside County Substations

Site #	WECC #	Bus Name	ETWC
1	25623	Terawind	120
2	25635	Altwind	117
3	25639	Seawind	120
4	25633	Capwind	120
5	25645	Venwind	117
6	25634	Buckwind	120
7	25646	Sanwind	119
8	25636	Renwind	120
9	25637	Tranwind	120
Total			787

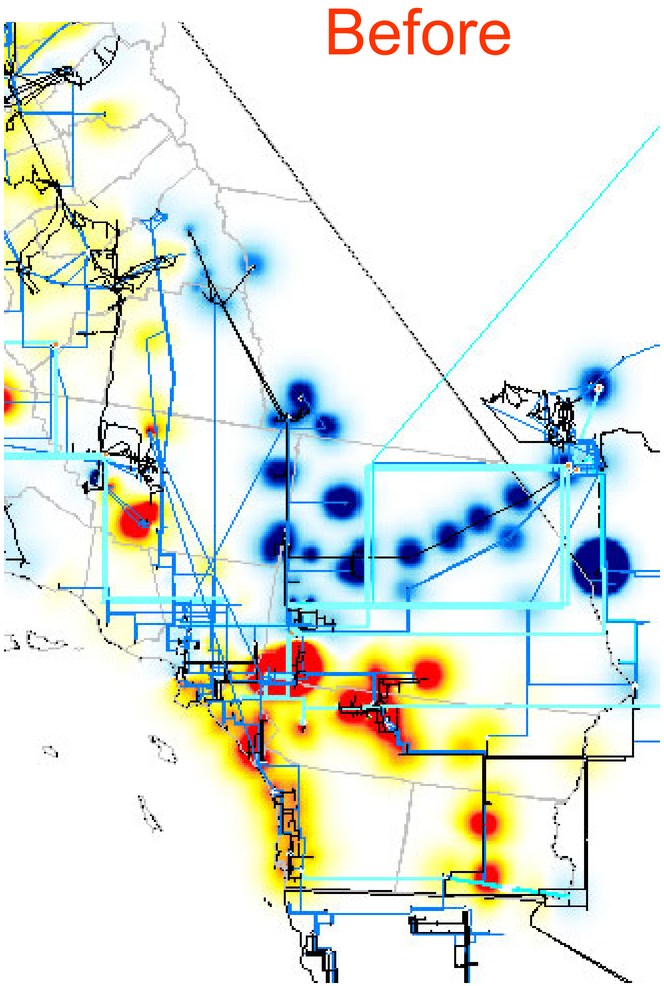
Riverside County Wind Site

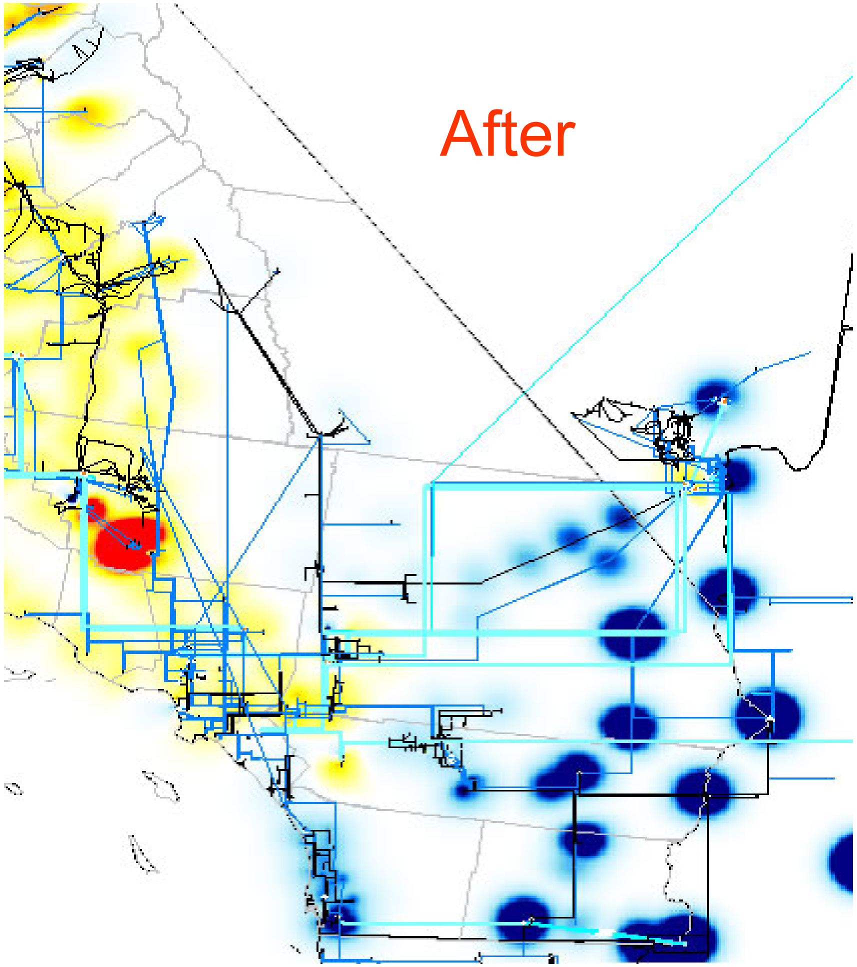
- 1,416 MW of high wind technical potential
- Located in northwest corner of county
- Extensive wind development
- Nine substations selected to install additional wind generation
- 787 MW ETWC on existing transmission system

Projected AMWCO

- ETWC capacity 787 MW
- AMWCO Impact -1,098 MW
- Impact Ratio - 1.40
- Wind power generation will be competing with Desert Southwest energy for space on the existing 500 kV transmission line

2010 Riverside After Hot Spot





Riverside Development Impacts

- Although the Riverside wind sites show a benefit to the system, it also shows the stress it places on the transmission system.
- More blue areas show up since the system is being stressed to support the exporting of wind power.
- Indicates that if Riverside is developed, California needs to upgrade the high voltage transmission system to continue supporting imports and other renewable technology development.

San Diego County Wind Site

- 756 MW of technical wind potential
- Located in southeastern corner of county
- Nearest bus is a 69 kV (Glencliff)
- Two part analysis; (1) install wind on 69 kV; and (2) install new 138 kV line

Preliminary Results

- 30 MW ETWC can be installed on 69 kV without causing line overloads
- AMWCO increases (Impact ratio = (1.13)
- Voltage in area improves
- Increase in AMWCO; increase in voltage

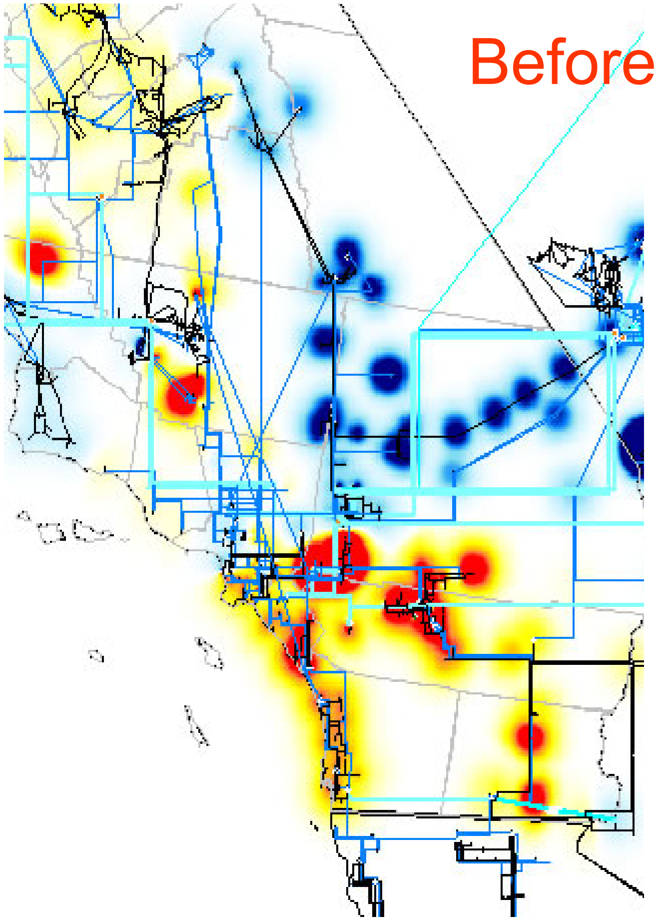
Preliminary Cont’d

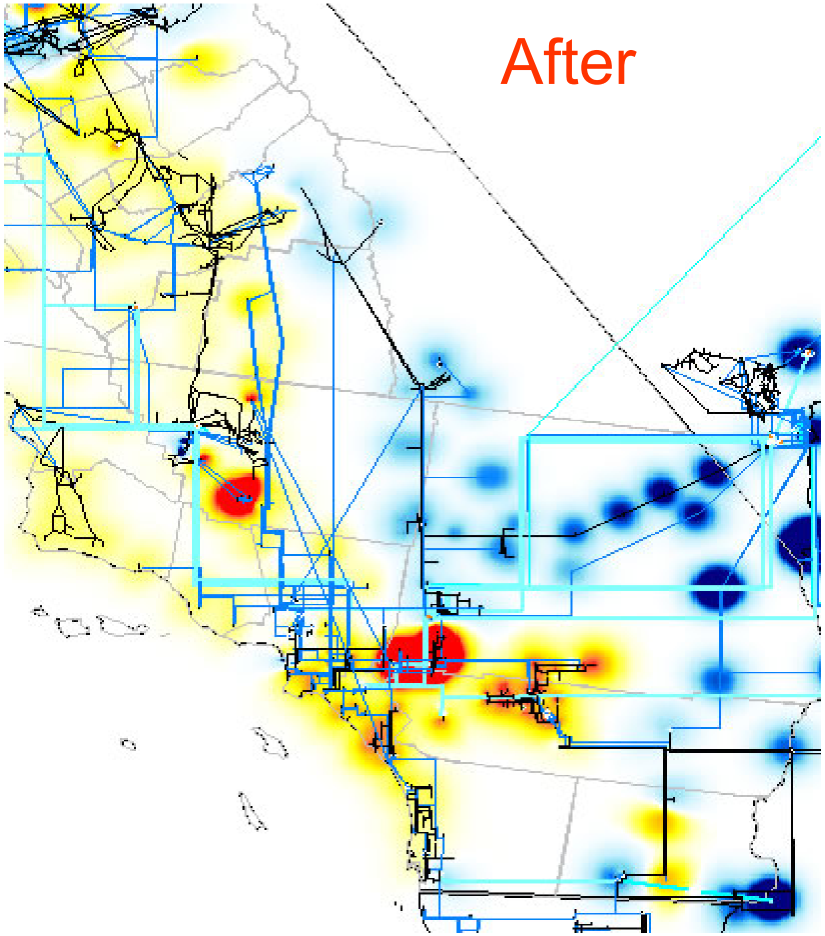
- Next 60 MW ETWC requires a 138 kV substation and line to Los Coches
- Requires additional 69 kV and 138 kV reconductoring on Los Coches interconnections

Projected AMWCO

- First 30 MW ETWC
  - AMWCO +34 MW
  - Impact ratio + 1.13
- Full 90 MW ETWC
- AMWCO Impact -144 MW
- Impact ratio -1.6

San Diego Hot Spot



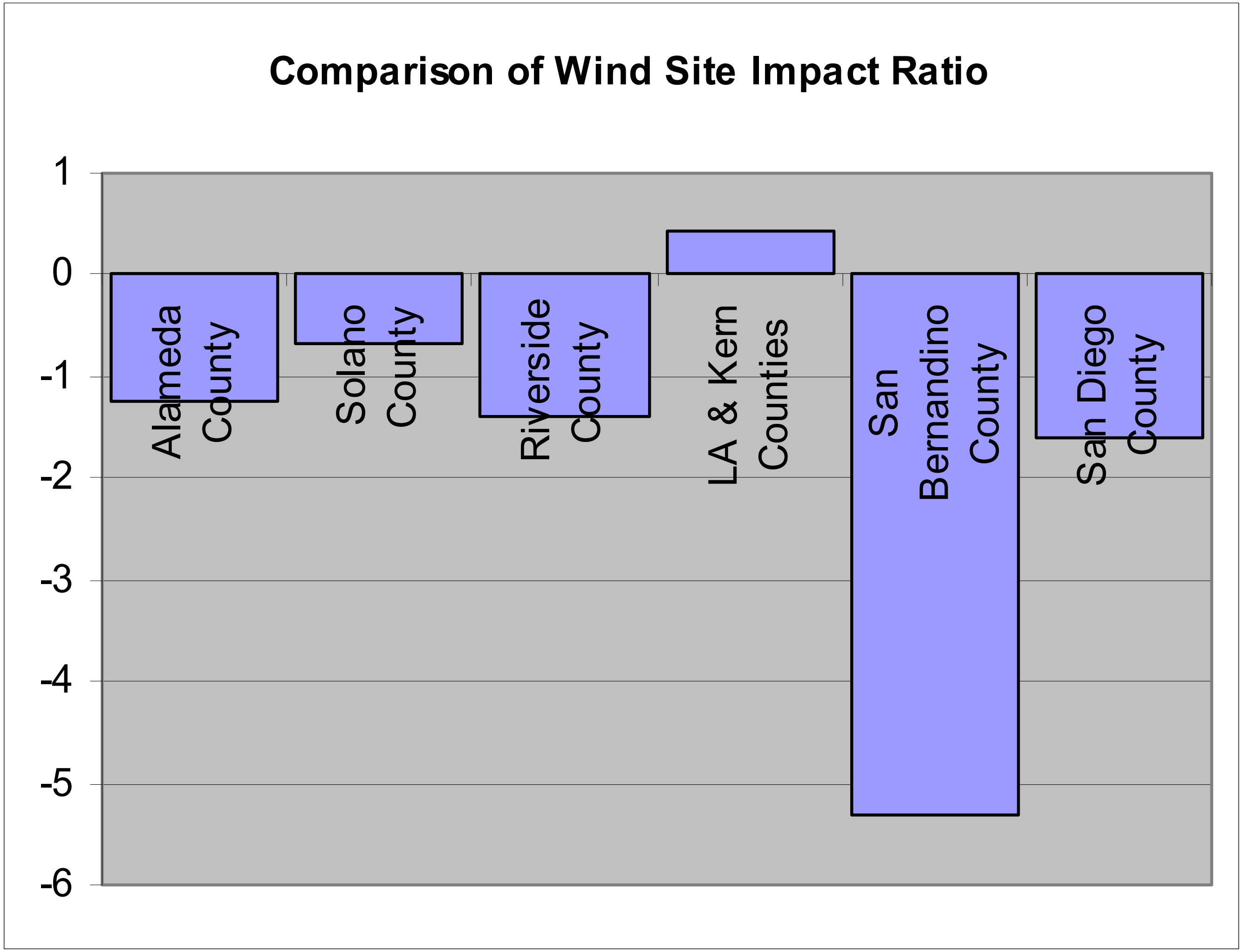


San Diego Conclusions

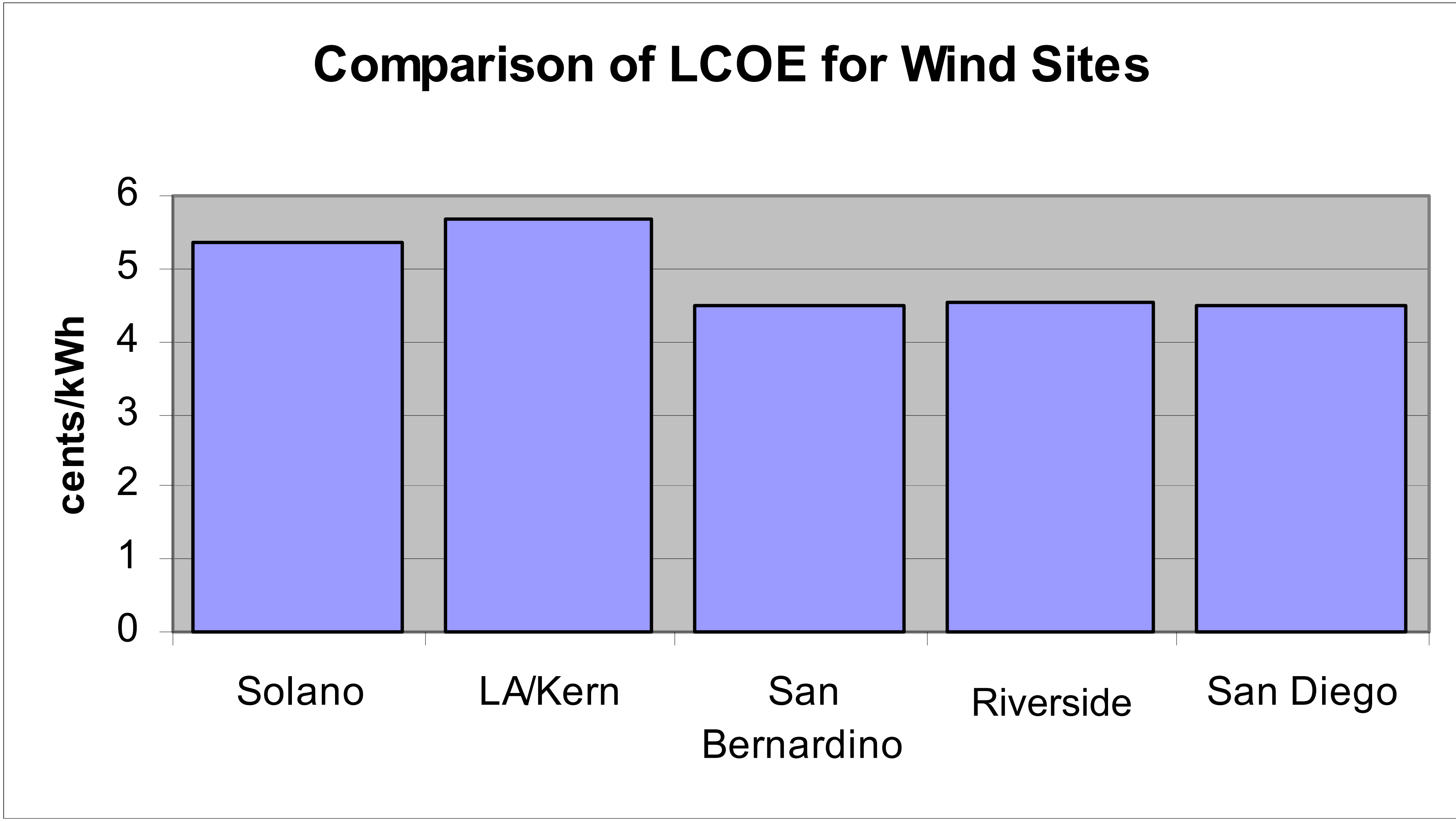
- Initial 69 kV installation allows for immediate wind construction and public benefits
- 138 kV line development allows for more exporting of wind power but causes more transmission overloads on other lines

Conclusions Cont'd

- SDG&E projects 30 MW wind on 69 kV; 195 MW if the 138 kV line constructed
- SDG&E projects overloads on other lines in exporting wind power from this site similar to the DPC results



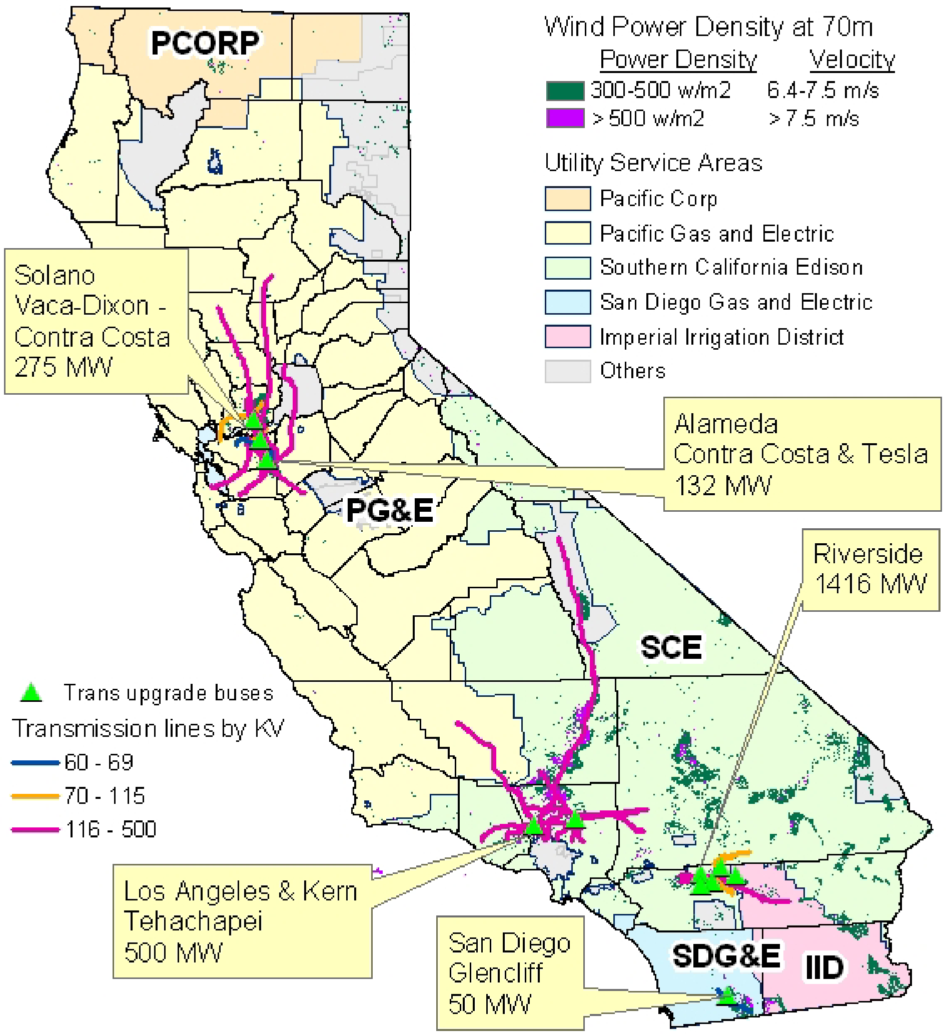
Comparison of Wind Site Impact Ratio
1
0
-1
-2
-3
-4
-5
-6
Alameda County
Solano County
Riverside County
LA & Kern Counties
San Bernandino County
San Diego County


Comparison of LCOE for Wind Sites
cents/kWh
0
1
2
3
4
5
6
Solano
LA/Kern
San Bernardino
Riverside
San Diego

Comparison of Wind Potential vs. ETWC

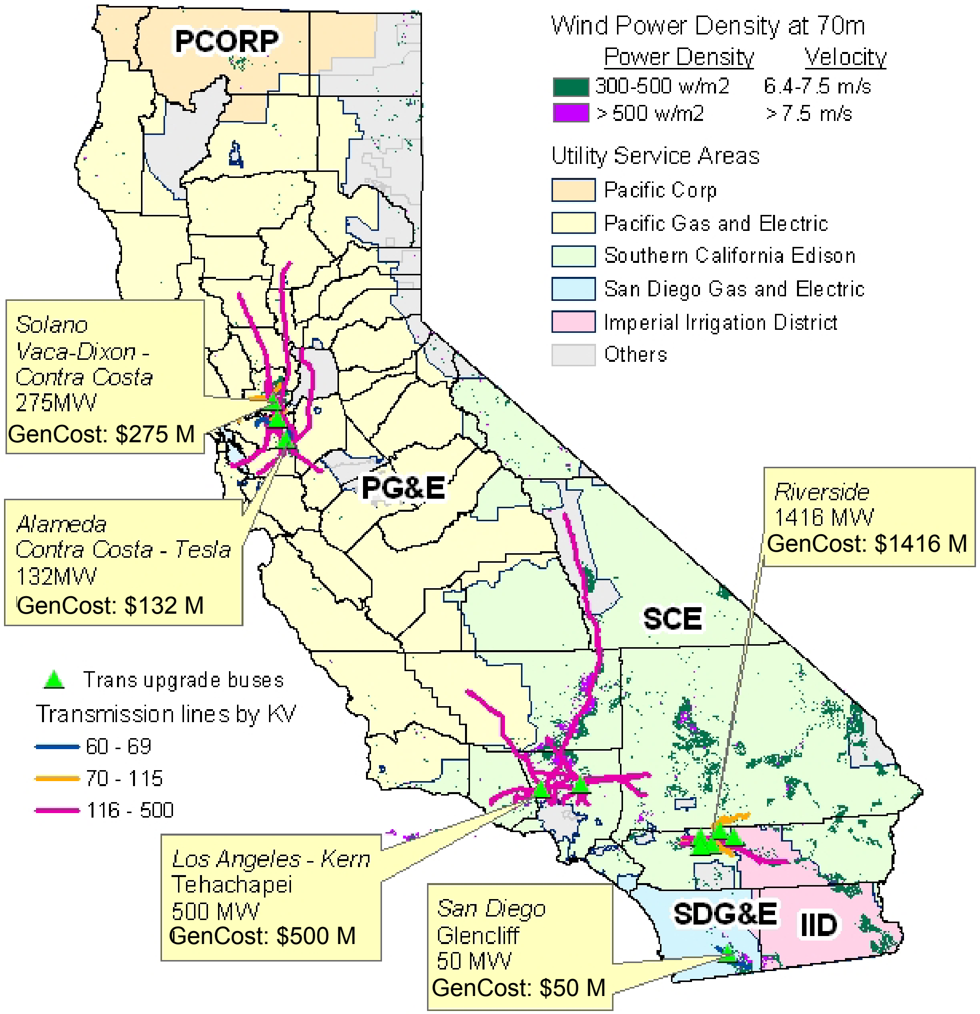
County	High Wind Speed Potential (MW)	ETWC At Summer Peak (MW)
Alameda	132	79
Solano	275	165
Riverside	1,416	787
LA/Kern	2,038	300
San Bernardino	280	168
Imperial	82	Did not study
San Diego	756	90
Total	4,979	1,589

Projected Wind Generation Viable by 2010



These capacity additions were based on only those high speed wind resources within proximity to existing transmission access

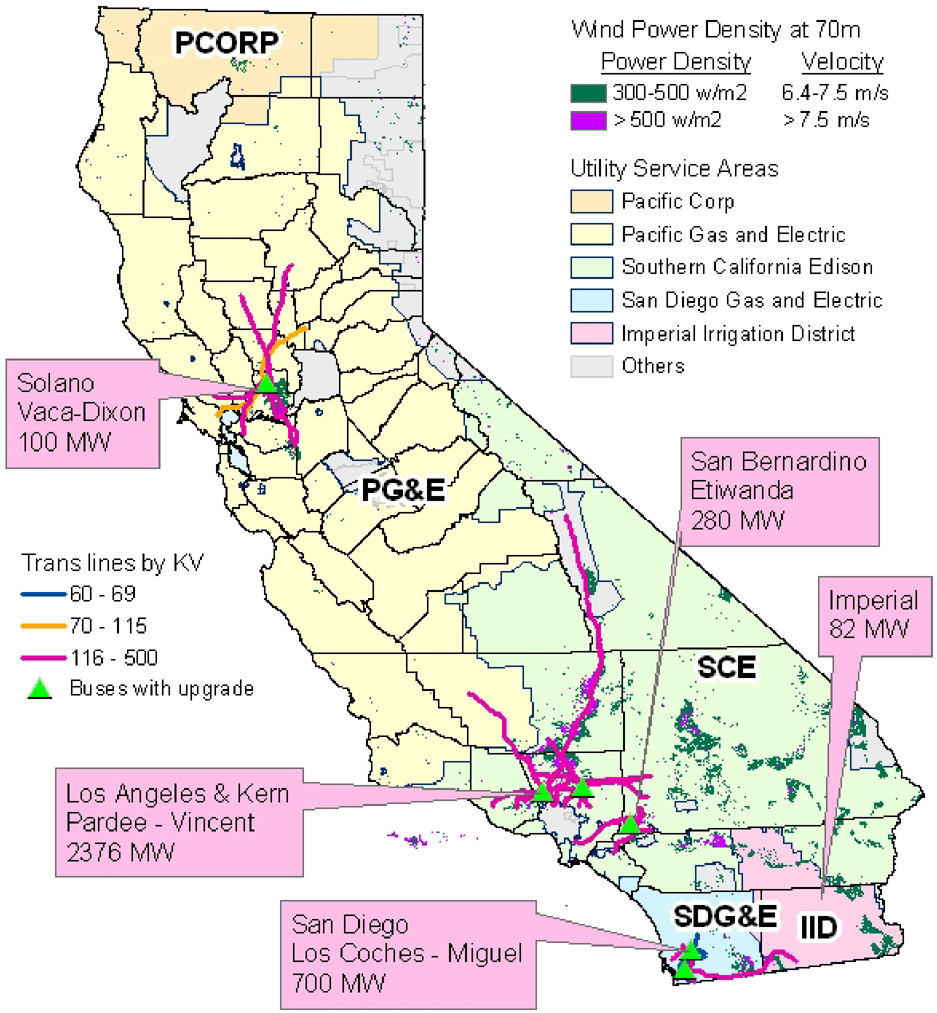
Wind Generation Capacity and Costs by 2010



Note there are no transmission costs as these capacity additions can occur without major transmission upgrades

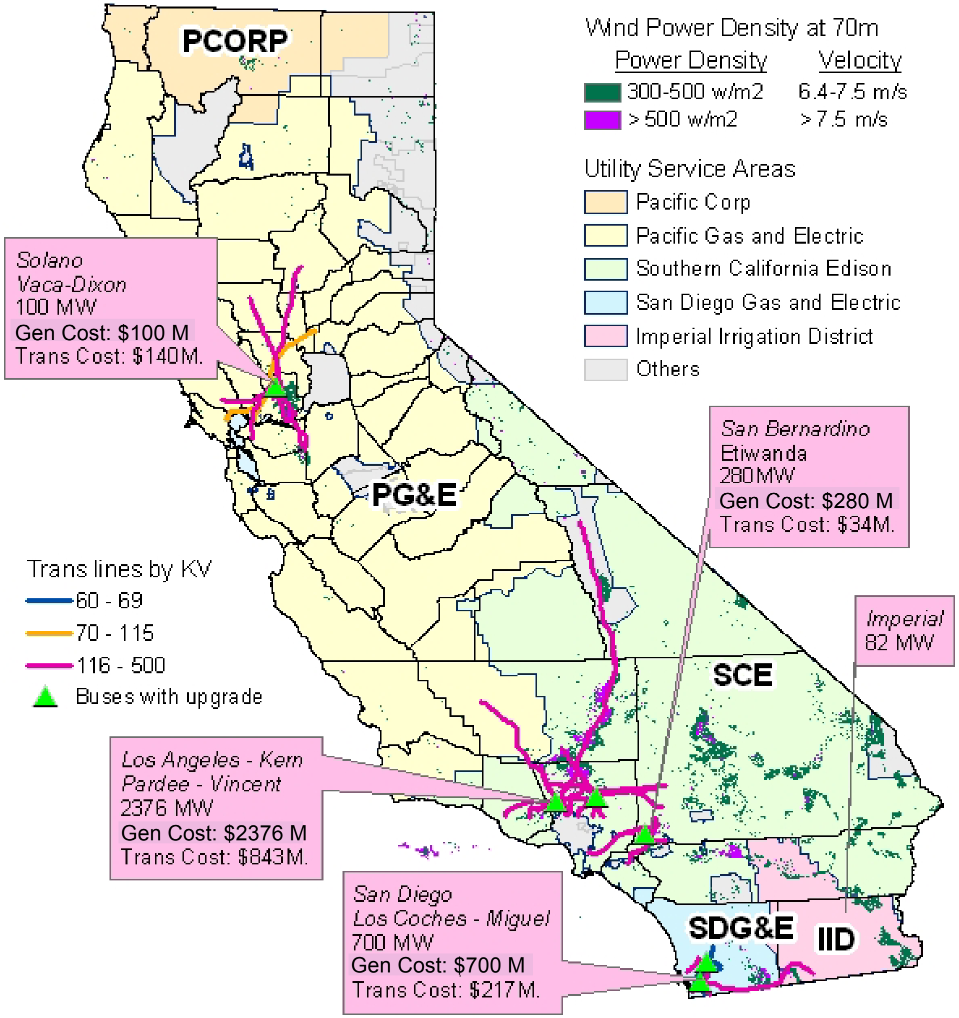
Total capacity additions at ~2370 MW and total cost of $2.4 billion

Projected Wind Generation Viable by 2017

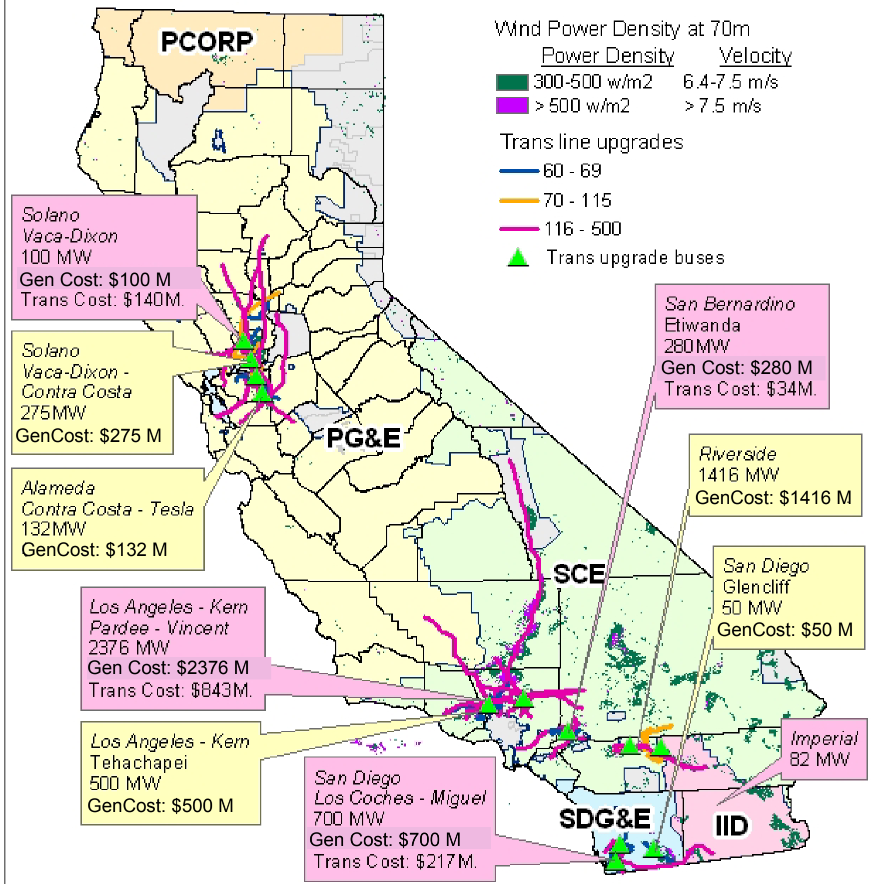


Total of over 3500 MW by 2017

Wind Generation Capacity and Costs by 2017

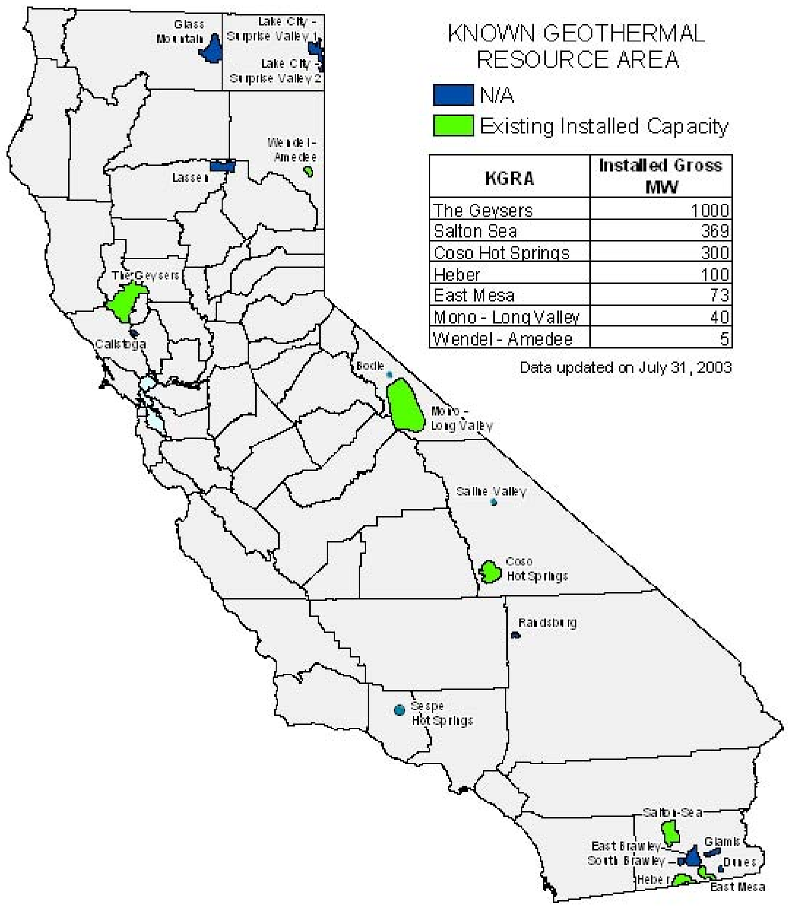


Combined 2010 and 2017 Wind Development Prospects



2010 developments in yellow; 2017 in pink

Existing CA Geothermal Developments



KNOWN GEOTHERMAL RESOURCE AREA

- N/A
- Existing Installed Capacity

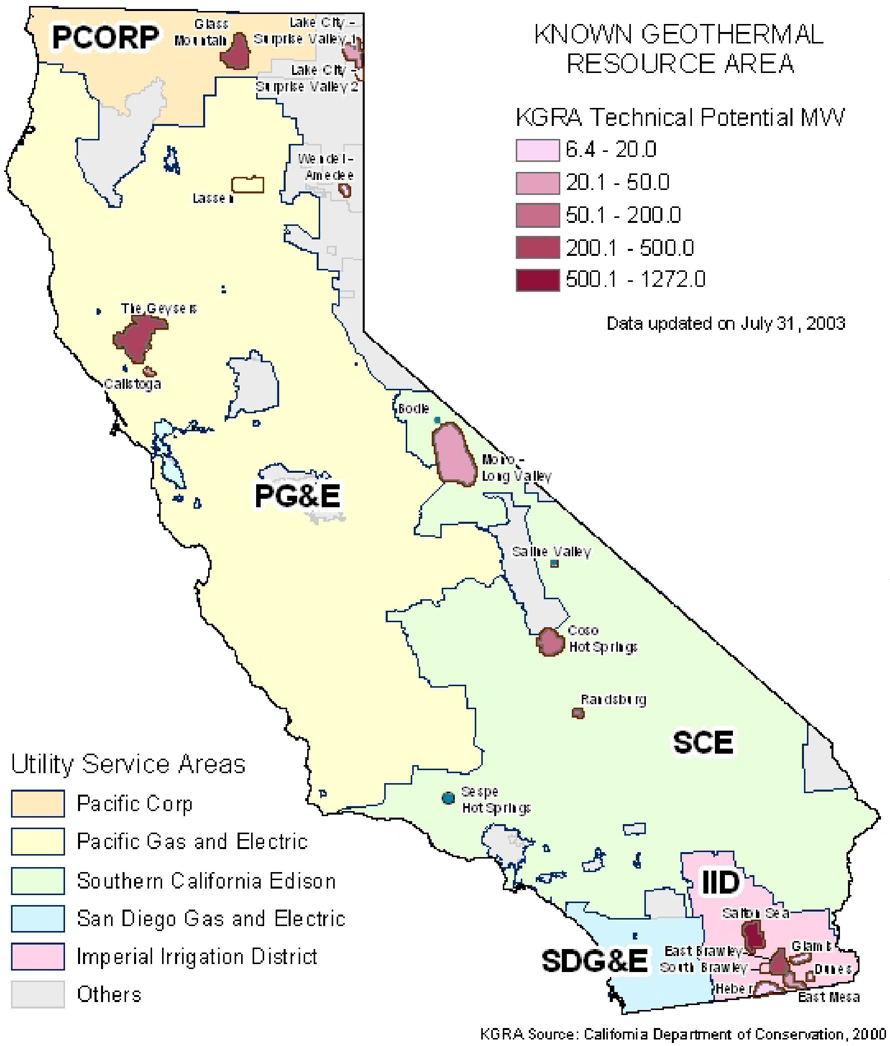
KGRA	Installed Gross MW
The Geysers	1000
Salton Sea	369
Coso Hot Springs	300
Heber	100
East Mesa	73
Mono - Long Valley	40
Wendel - Amedee	5

Data updated on July 31, 2003

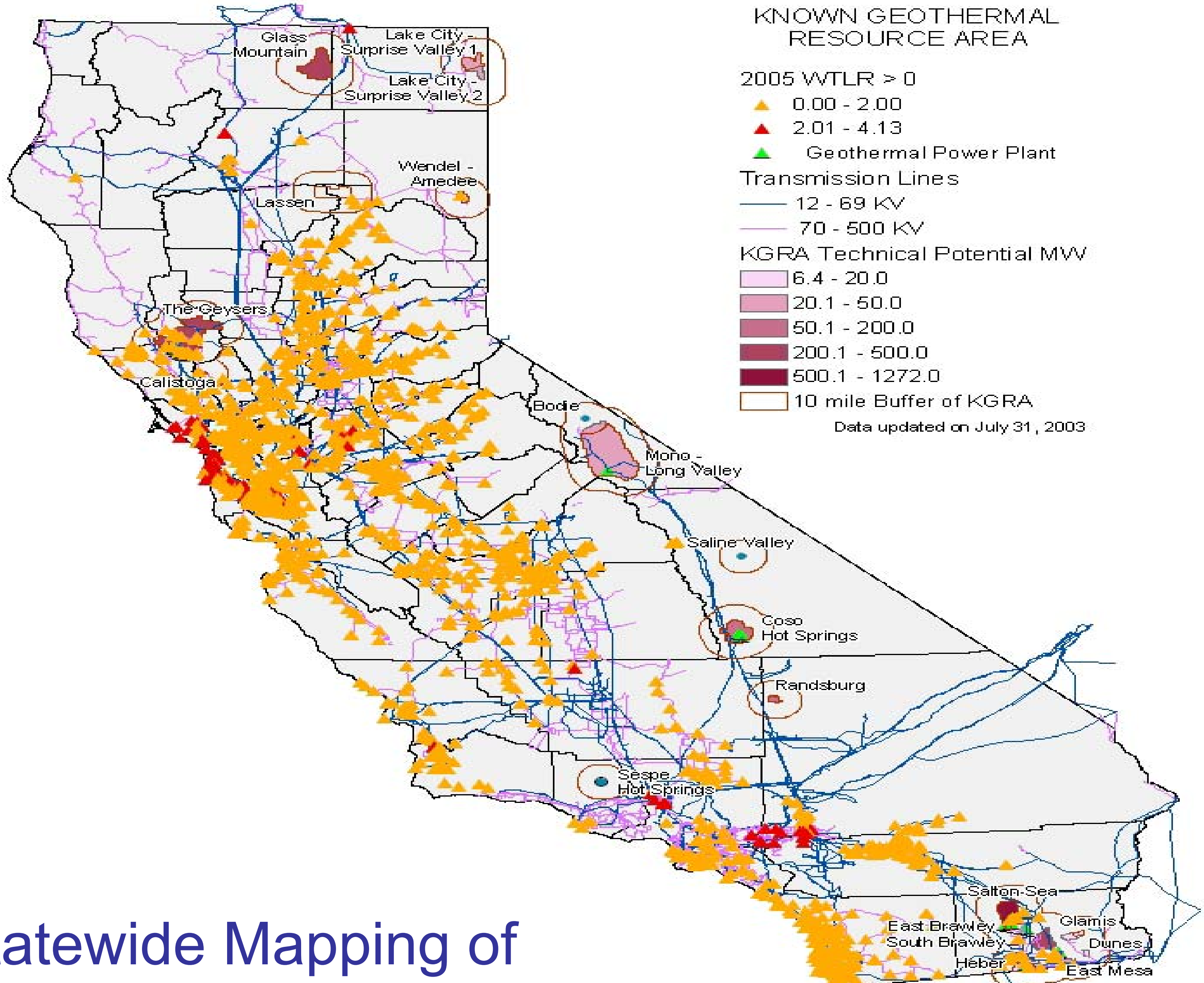
Source: California Department of Conservation, 2000

Total statewide installed geothermal capacity ~1990 MW

Geothermal Technical Potential



Statewide technical potential over 3800 MW



Statewide Mapping of Geothermal To Hot Spots for 2005

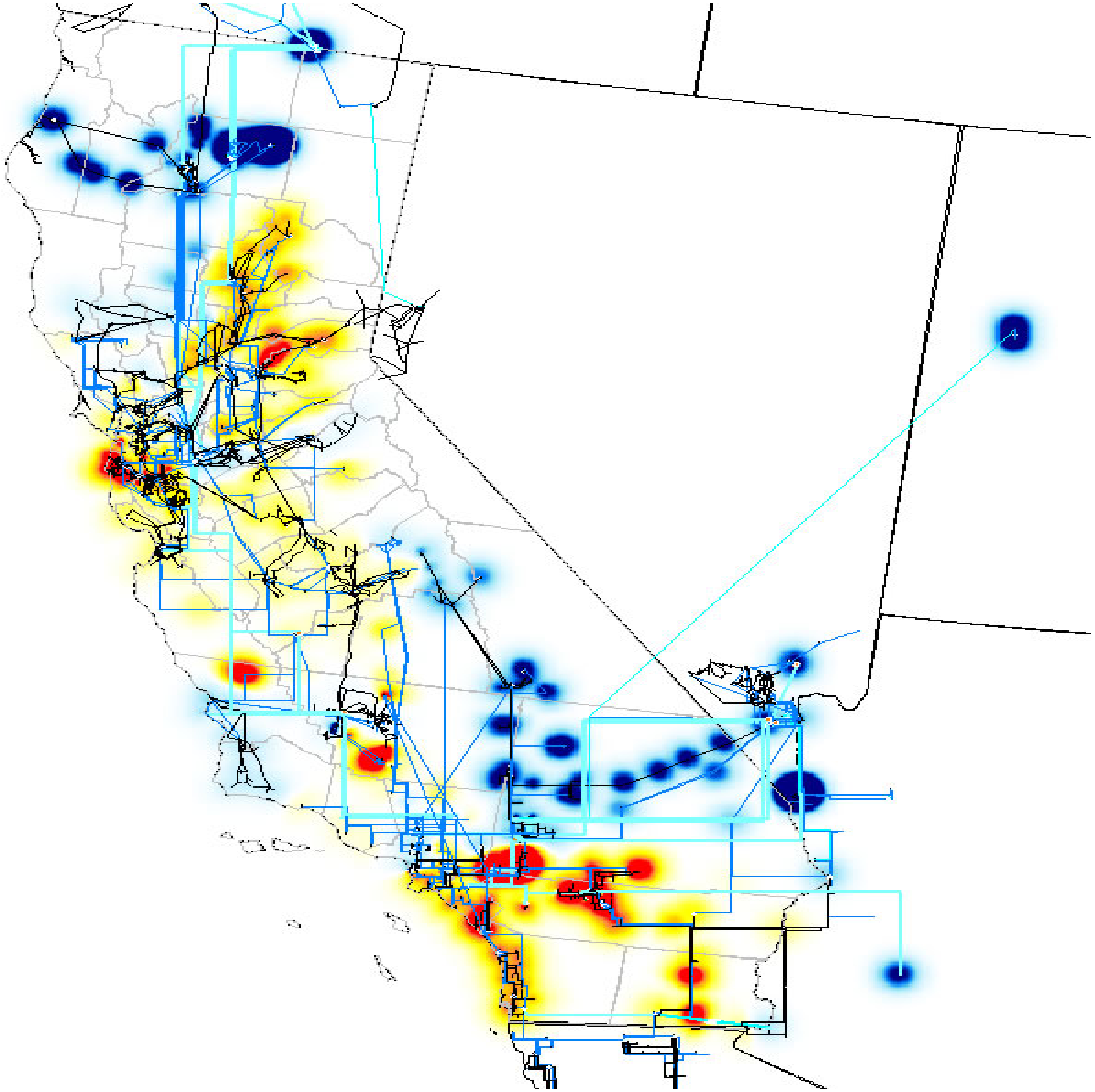
Source: California Department of Conservation, 2000

Selection of Geothermal Sites

- Determine geothermal technical potential
- Prepare GIS maps of the locations
- Overlay the transmission hot spots
- Select sites for solution analysis
- Calculate the benefit ratio

- AMWCO – Aggregated Megawatt Contingency Overload

2010 Hot Spots –Base Case



IOU Geothermal Sites

Service Territory	Location	County	Size (MW)
PG&E	Geysers	Lake	100
	Sulfur Bank Field	Lake	52
	Geysers	Sonoma	300
	Calistoga	Napa	30
	Honey Lake	Lassen	8
PacifiCorp	Lake City	Modoc	42
	Medicine Lake	Siskiyou	452
SCE	Coso Hot Springs	Inyo	149
	Long Valley	Mono	47
	Randsburg	San Bernardino	62
	Sespe Hot Springs	Ventura	6
		Total	1,248

Imperial Valley Sites

Service Territory	Location	County	Size (MW)
IID	Brawley	Imperial	242
	Dunes	Imperial	15
	East Mesa	Imperial	42
	Glamis	Imperial	9
	Heber	Imperial	20
	Salton Sea	Imperial	1,171
	Mount Signal	Imperial	24
	Niland	Imperial	65
	Superstition Mint.	Imperial	12
		Total	1,600

Geysers (Lake County and Sulfur Bank Field)

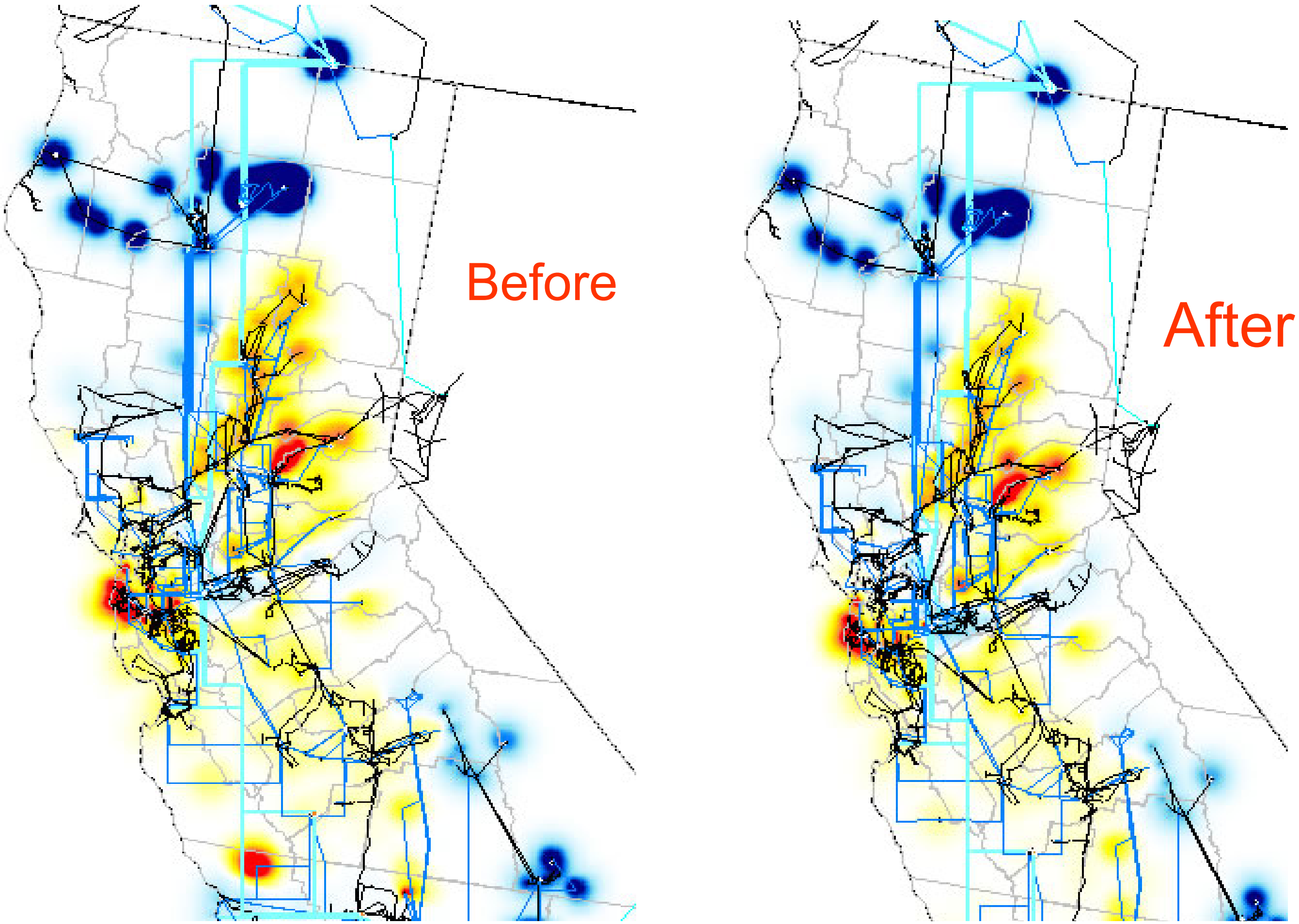
- 152 MW total potential
- Located in north end of existing fields
- Connected to Eagle Rock substation (bus 31220)
- Creates transmission overloads in area
- Requires new transformer at Eagle Lake and new 230 kV transmission line between Eagle Lake and Fulton substations

Projected 2010 Lake County AMWCO Benefit

• Installed Capacity	152 MW
• AMWCO Impact	-442 MW
• Impact Ratio	-2.91

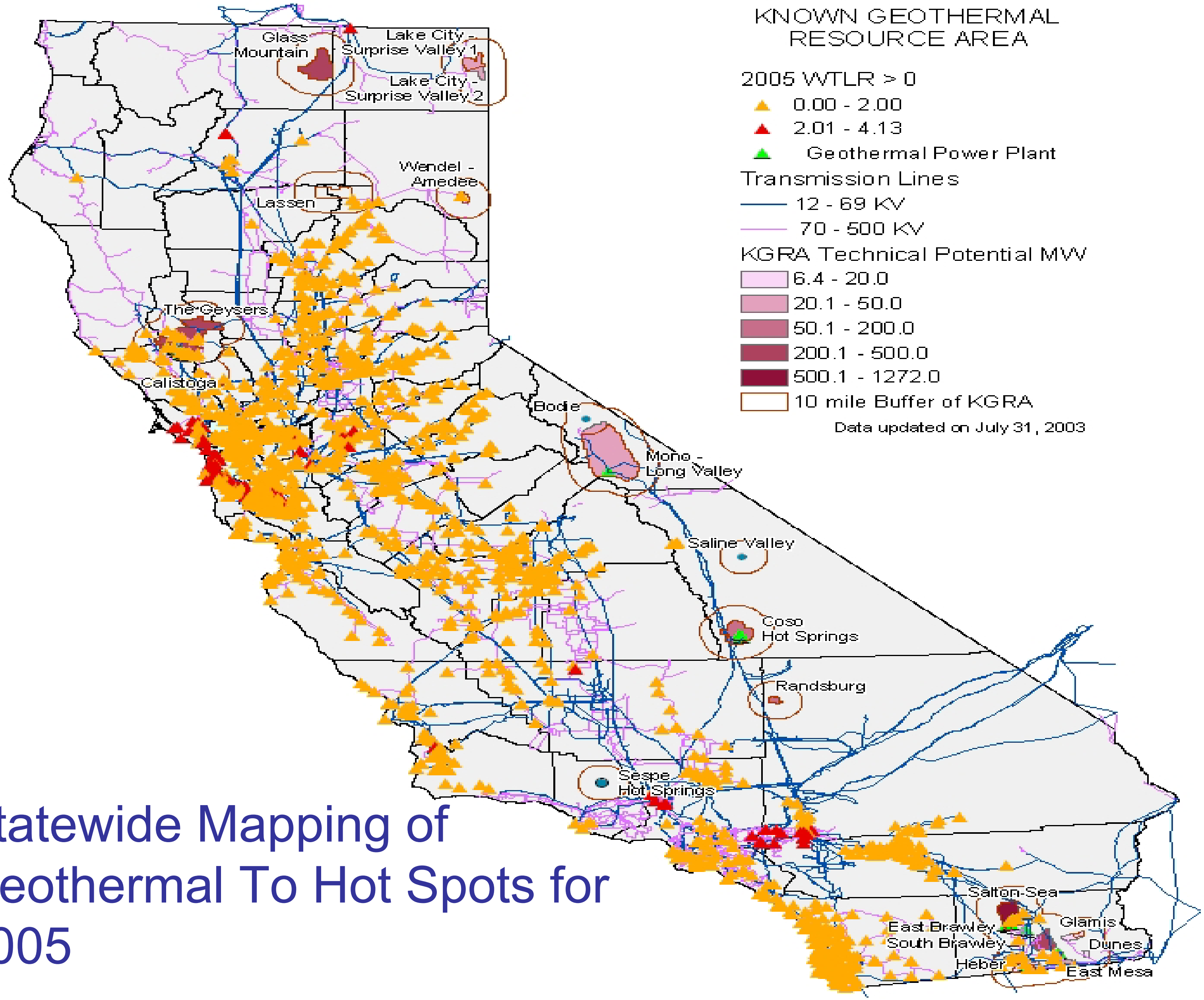
- Negative AMWCO is a benefit to the system

2010 Hot Spots – Lake County



Geysers at Sonoma County

- Technical potential 300 MW
- Located at south end of existing fields
- Connected to CR1T3_18 (30391)
- Creates transmission overloads
- Solution is to install second 230 kV line between CR1T4_23 (30419) and CR1T3_18 and two additional 230 kV lines between CR1T4_23 and Fulton (30430)



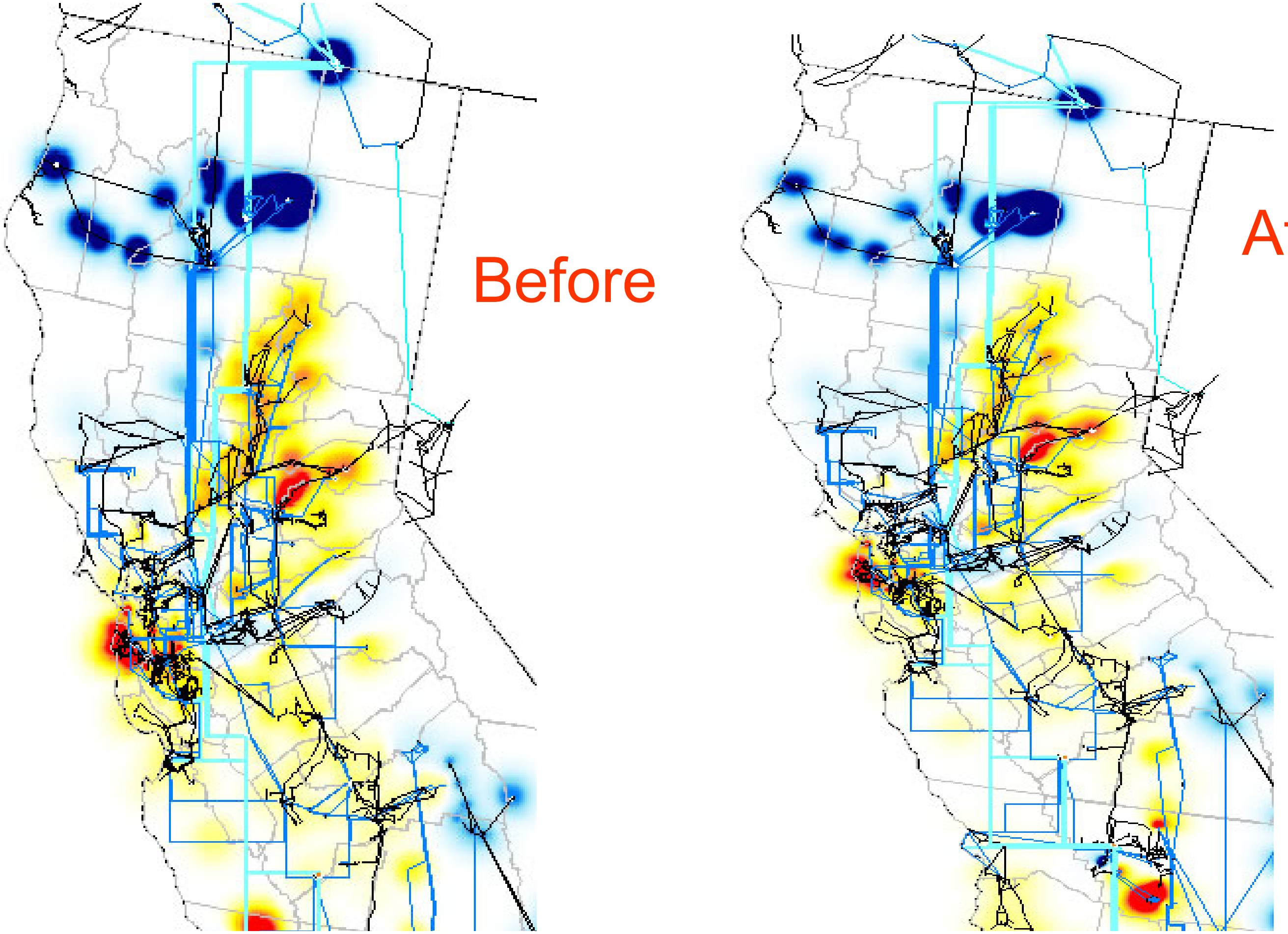
Statewide Mapping of Geothermal To Hot Spots for 2005

Projected AMWCO

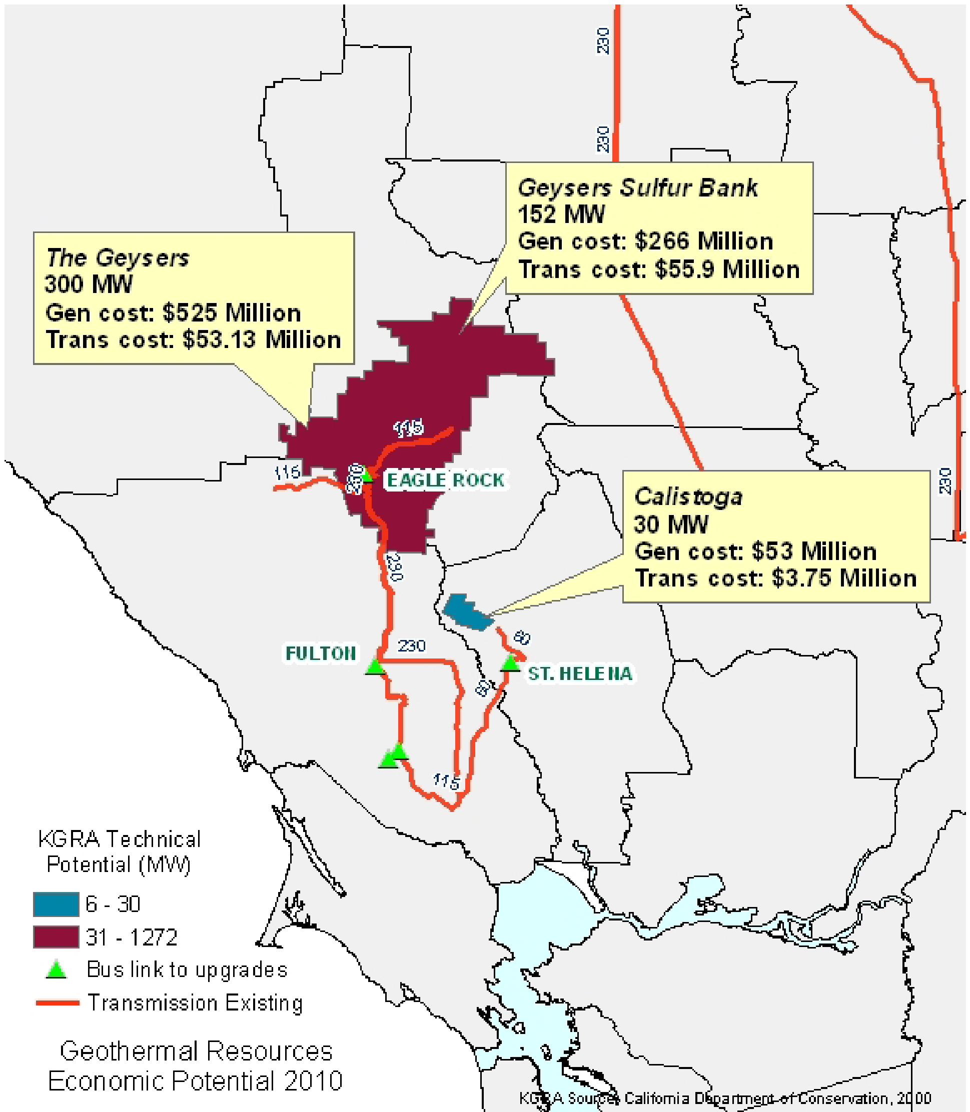
• Installed Capacity	300 MW
• AMWCO Impact	-670 MW
• Impact Ratio	-2.23

- If both Sonoma and Lake county sites constructed, then combine projects to improve overall benefits

2010 Hot Spots – After Sonoma County

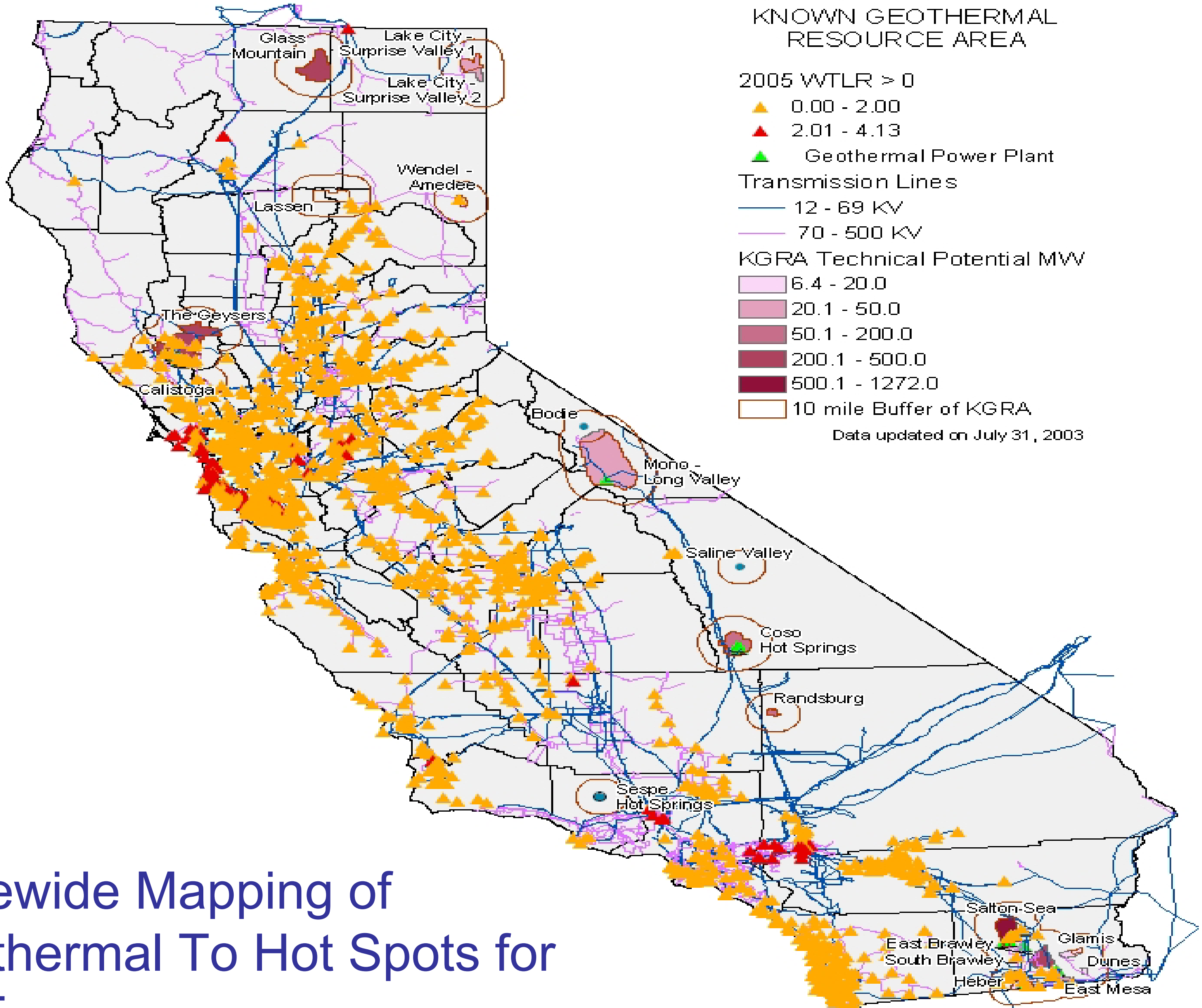


Detail on 2010 (Geysers) Geothermal Developments



Salton Sea in Imperial Valley

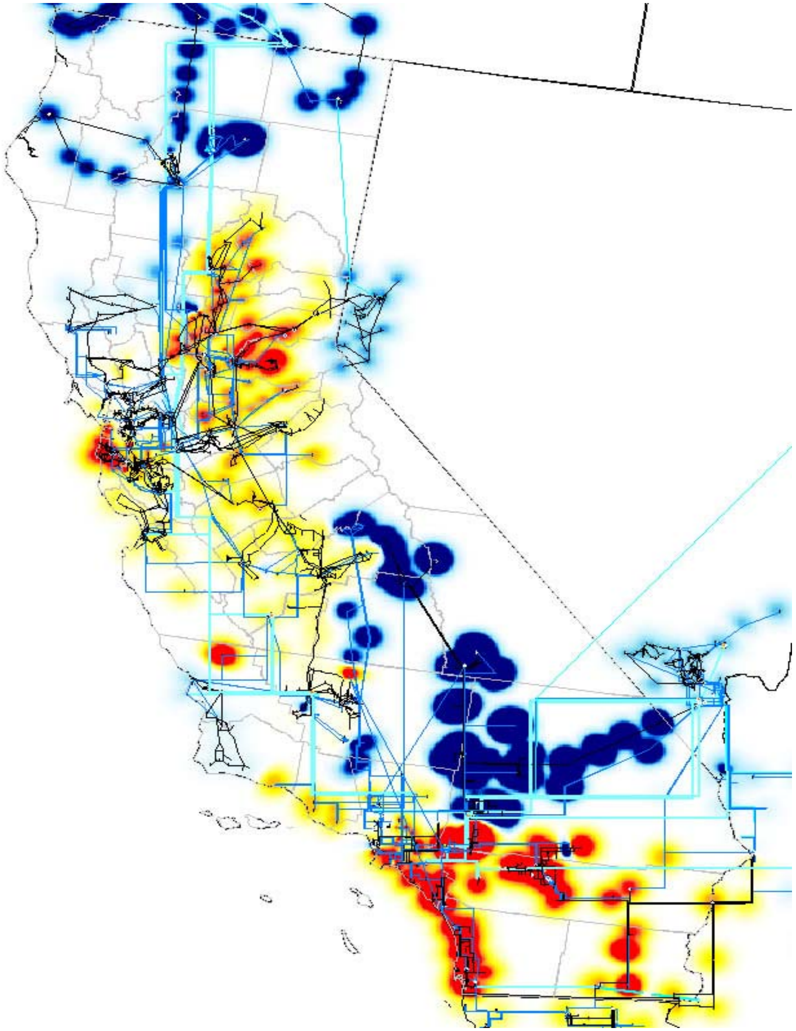
- Technical Potential 1,171 MW
- Located northeast of Salton Sea
- Large size requires 500 kV lines
- 500 kV expansion includes Devers to Mira Loma, Devers to Valley and Serrano, and Devers to new geo substation



Statewide Mapping of Geothermal To Hot Spots for 2005

Source: California Department of Conservation, 2000

2017 Hot Spot Map

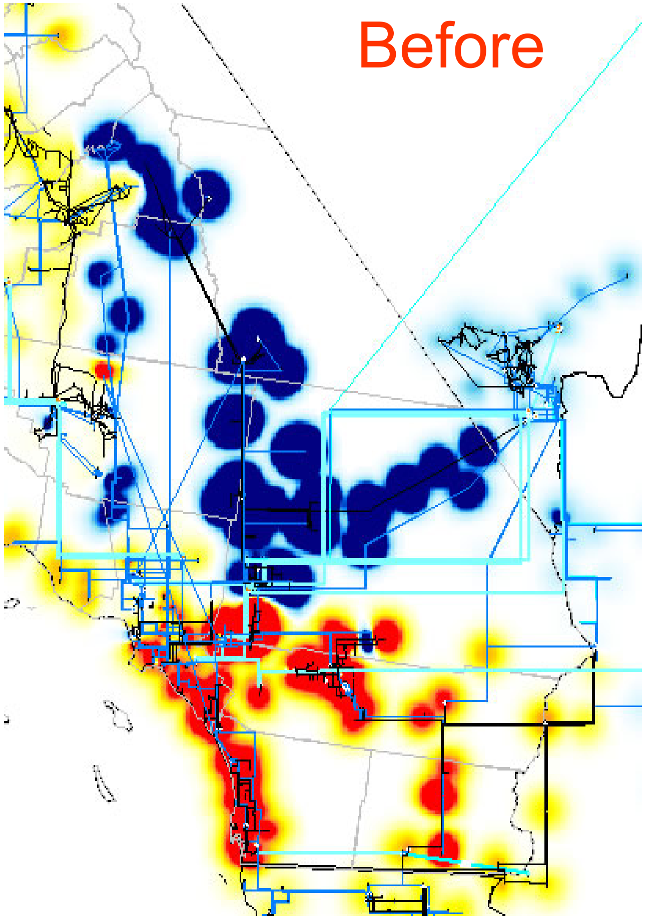


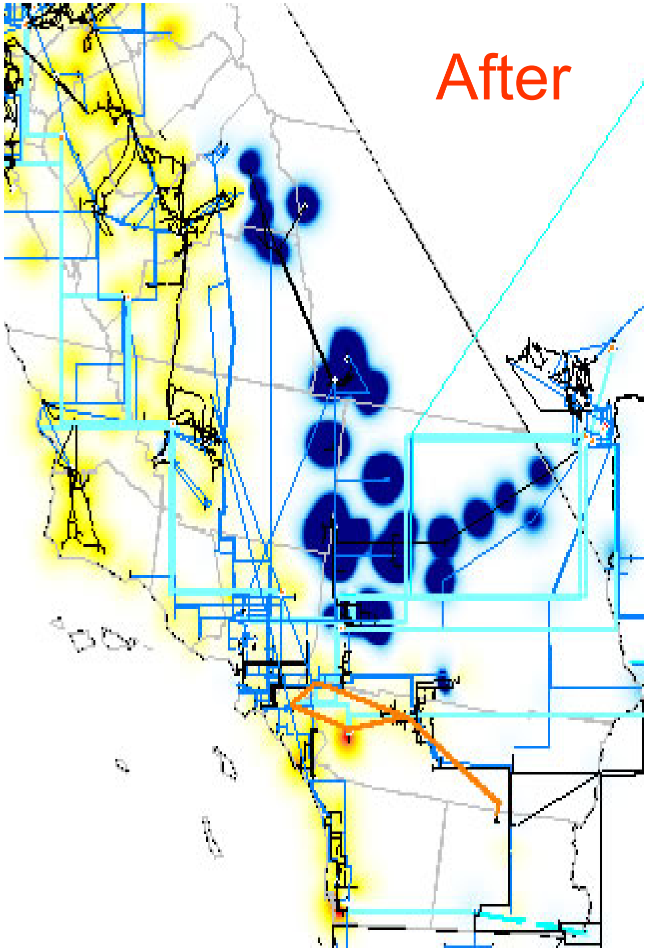
Projected AMWCO

• Installed Capacity	1,171 MW
• AMWCO Impact	-715 MW
• Impact Ratio	-0.61

- Even though ratio is less than 1.0, still a good project
- 500 kV development supported by SCE renewable concept plan

2017 Salton Sea Hot Spot After

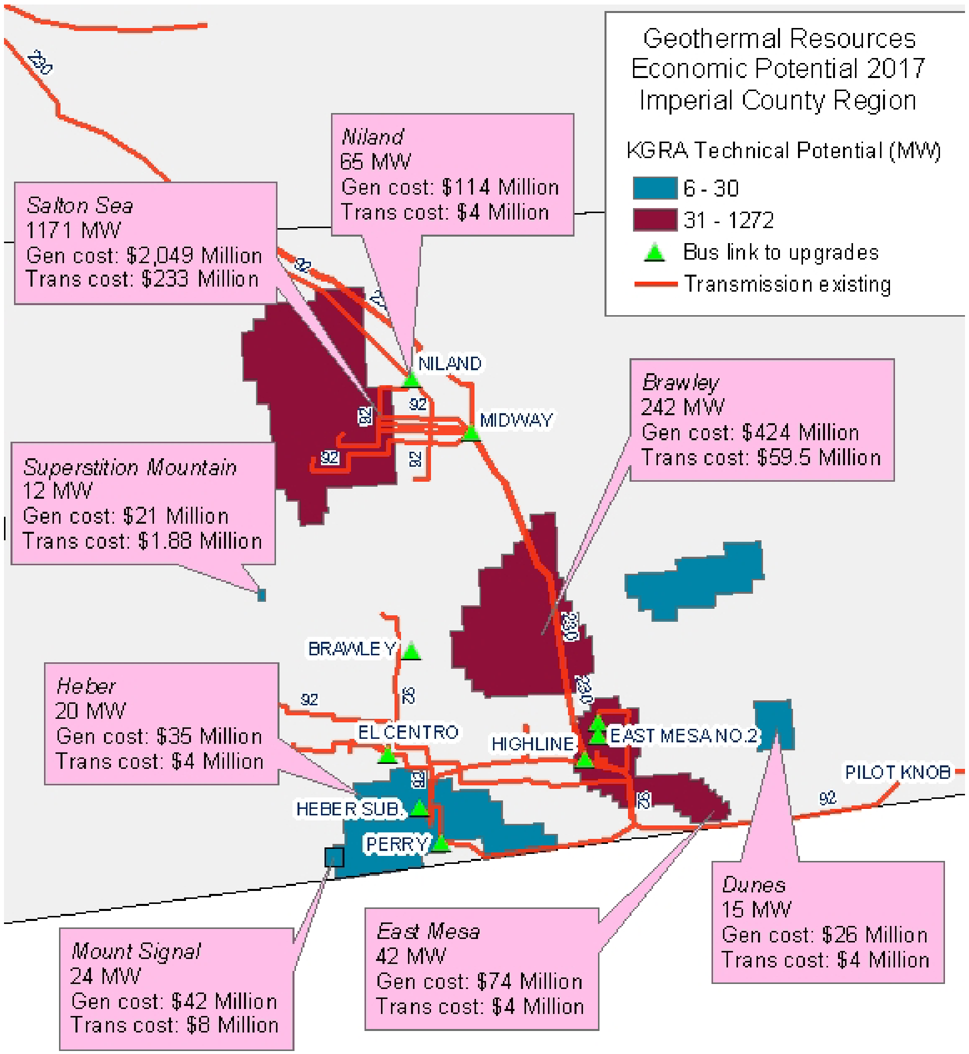




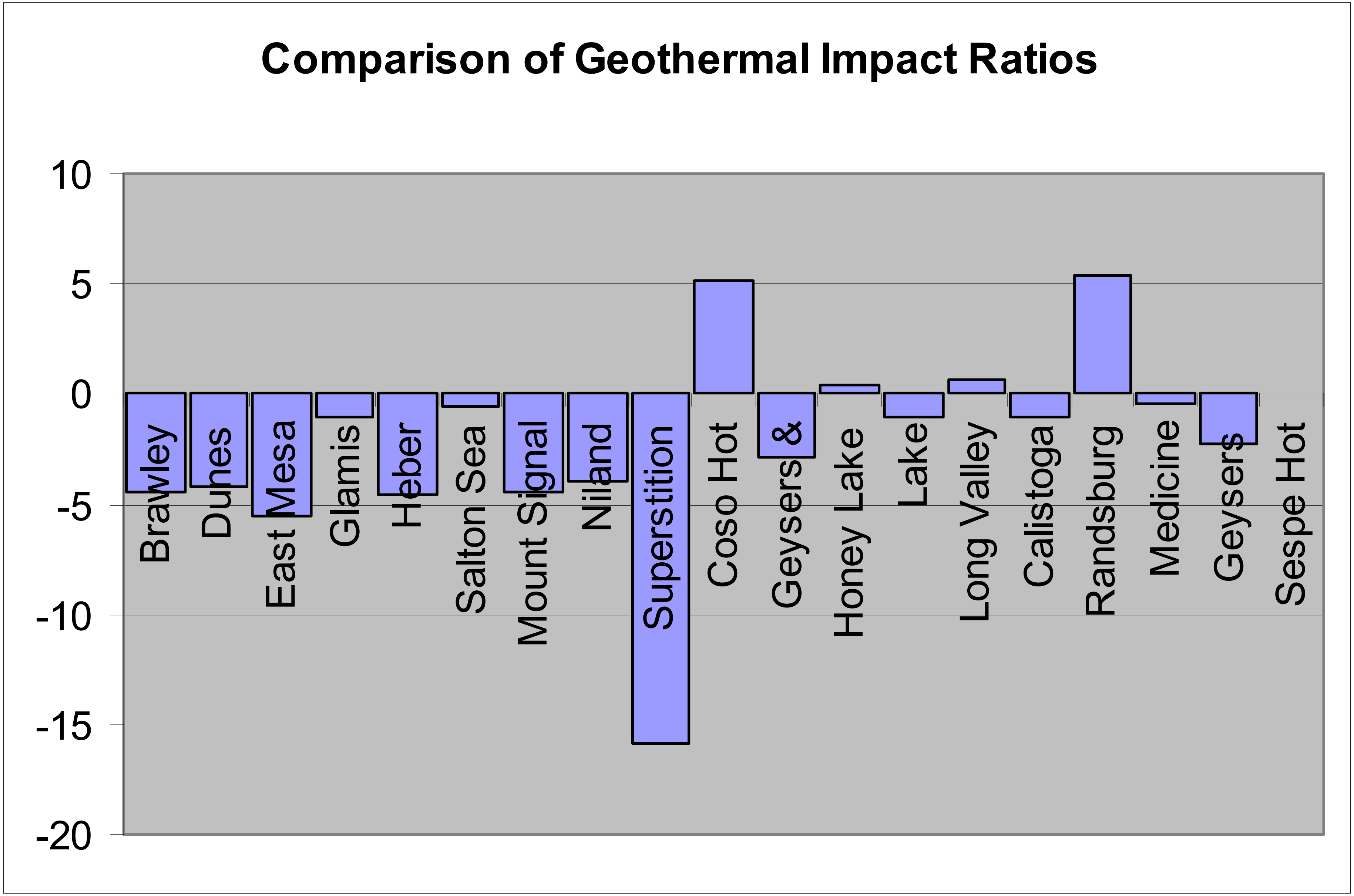
Salton Sea Transmission Impacts

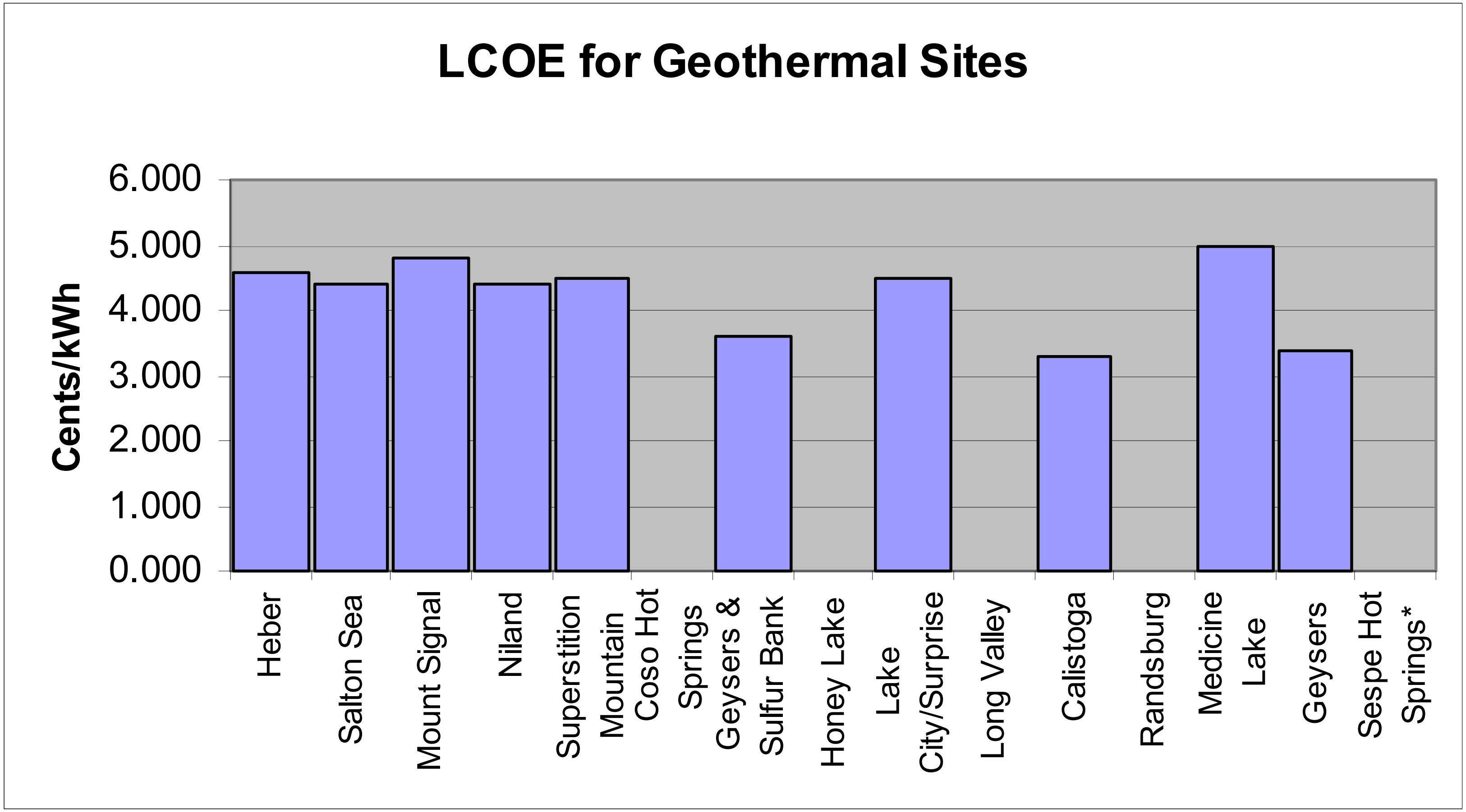
- Because there is new 500 kV transmission development to support the geothermal development, the entire region benefits from more imports, more generation and improved reliability
- If designed properly, other renewable regions (Riverside, Imperial, & San Diego counties) would benefit

Detail on Imperial 2017 Geothermal Developments



KGRA Source: California Department of Conservation, 2000


Comparison of Geothermal Impact Ratios
10
5
0
-5
-10
-15
-20
Brawley
Dunes
East Mesa
Glamis
Heber
Salton Sea
Mount Signal
Niland
Superstition
Coso Hot
Geysers &
Honey Lake
Lake
Long Valley
Calistoga
Randsburg
Medicine
Geysers
Sespe Hot



LCOE for Geothermal Sites
Cents/kWh
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Heber
Salton Sea
Mount Signal
Niland
Superstition Mountain
Coso Hot Springs
Geysers & Sulfur Bank
Honey Lake
Lake City/Surprise
Long Valley
Calistoga
Randsburg
Medicine Lake
Geysers
Sespe Hot Springs*

Renewable support in Transmission Planning

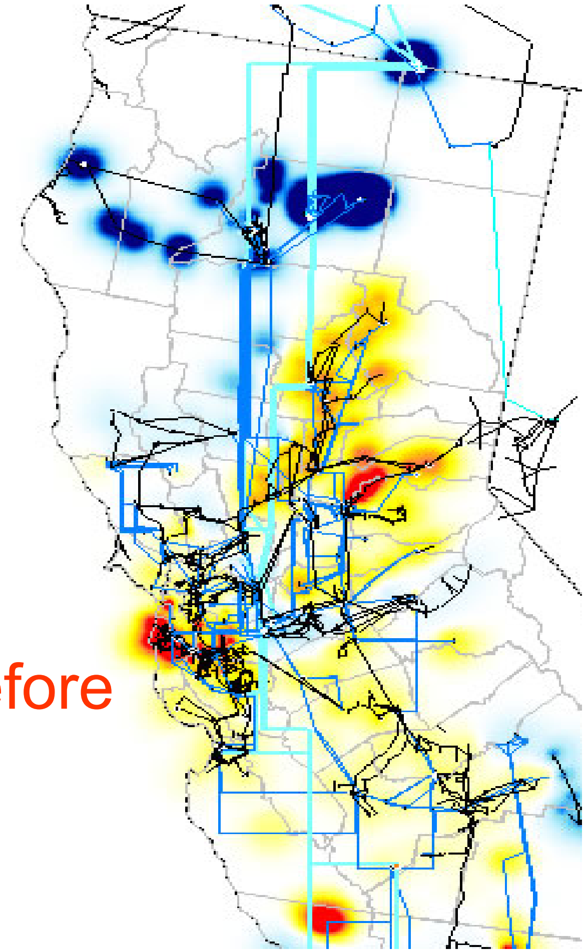
Selecting Transmission Options

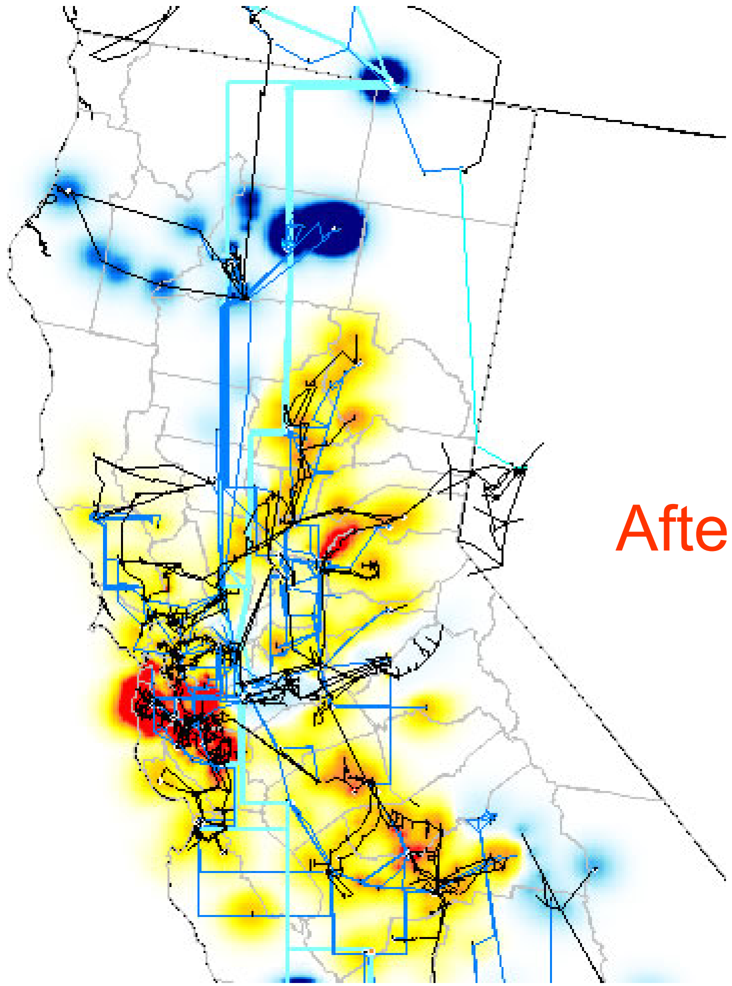
- Process can be used to value transmission development options by comparing AMWCO, public benefits and economics
- Process can compare transmission line development to generation expansion to renewable development

Potential Applications

- Aging power plants – Upcoming retirements
  - If retired, has load centers changed so that the existing site may not be the ideal location?
  - Where should new plants be located and what are the transmission requirements?
  - What role can renewable technologies contribute in locating new power plants?
- Retirement of Pittsburg units increases the AMWCO from 14,117 to 20,436 or 6,319

Retirement of Pittsburg Units





Applications Cont’d

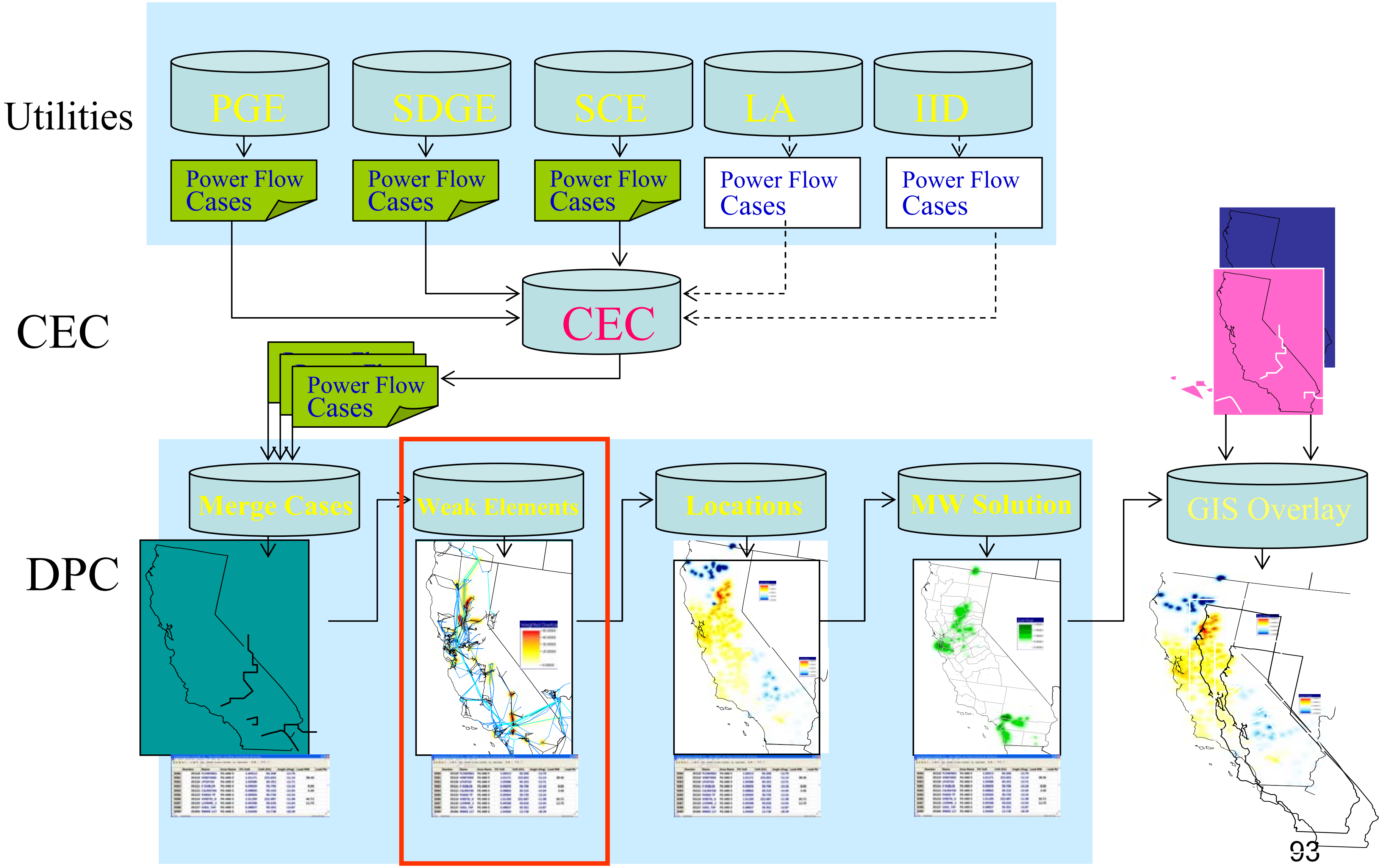
- Transmission Siting and Power Plant Siting
  - Can the transmission route also support central plant renewable technology development?
  - Can the power plant site also support some level of renewable development?
  - Can renewable development delay or reduce conventional development investment?

CALIFORNIA ENERGY COMMISSION

Renewable Transmission Planning Workshop

Identification of Weak Transmission Elements
(Hot Spots)

Project Overview

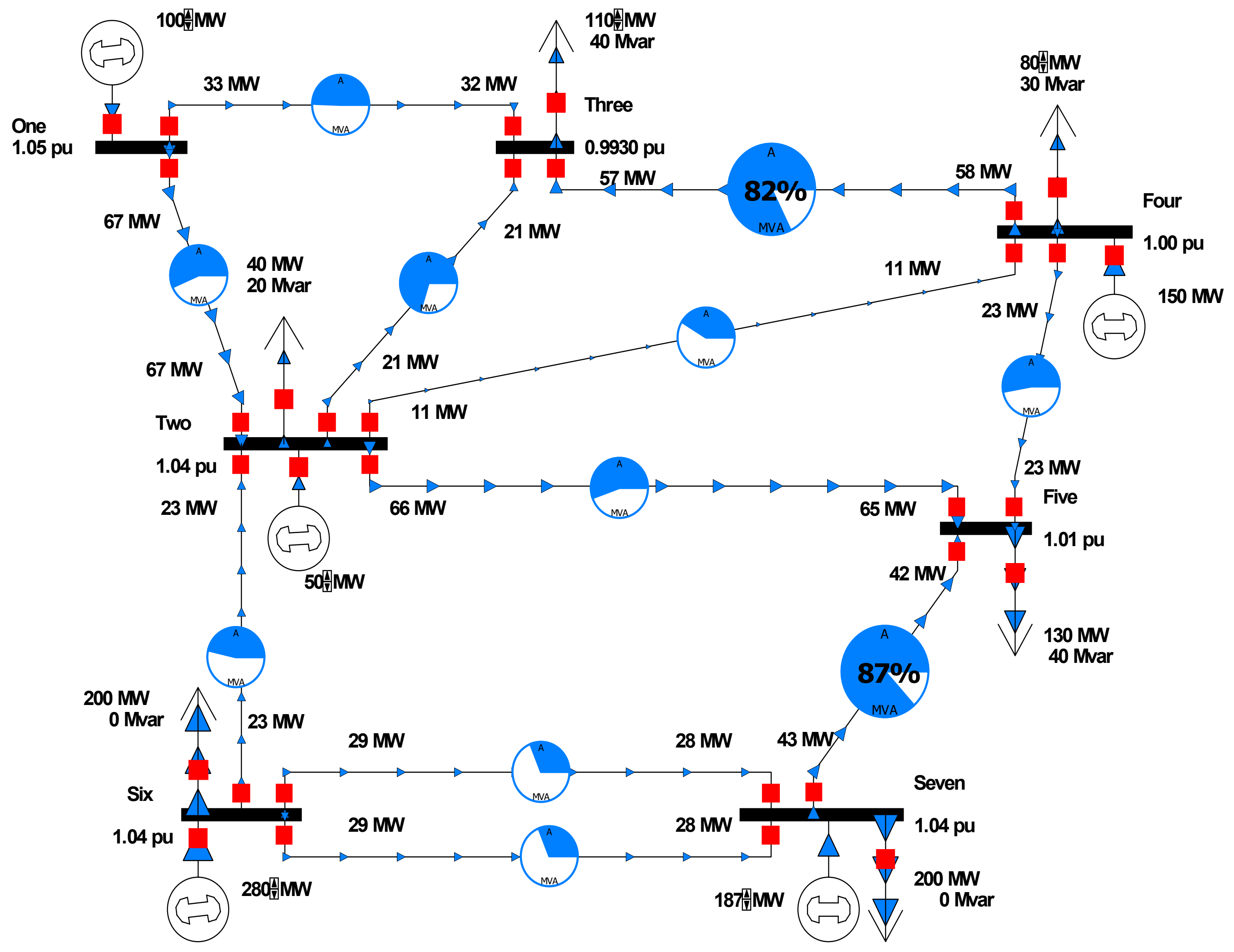


Overview

- Simulation
  - Power Flow
  - Contingency Analysis
- Results for California
  - Weak Elements
  - Security Indices
  - Visualization

Normal Operation Example:

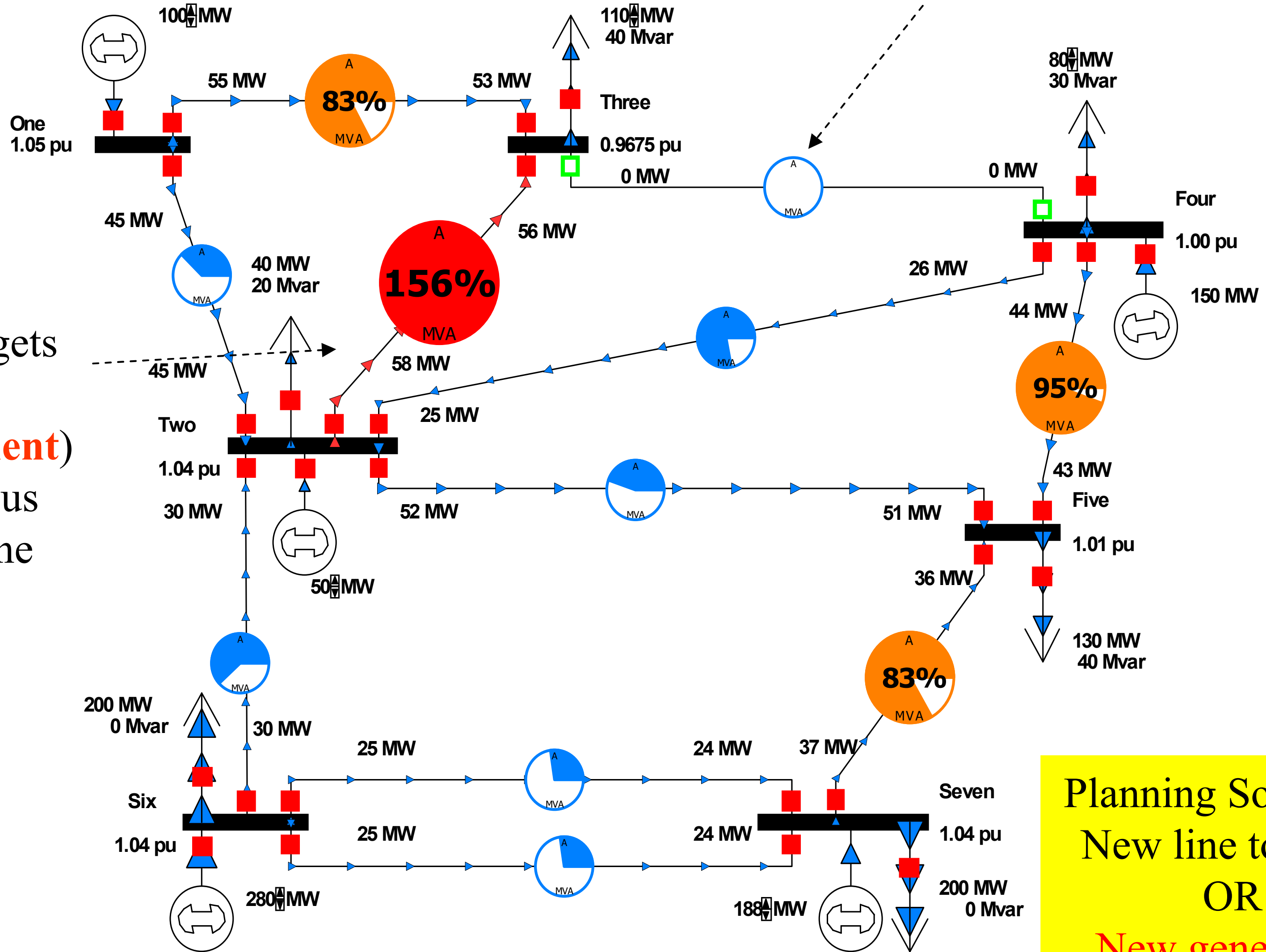
System does not have normal operation thermal violations



Contingency Example:

Suppose there is a fault and this line is disconnected

Then this line gets overloaded (is a **weak element**) This is a serious problem for the system



Planning Solutions:
New line to bus 3
OR
New generation at bus 3

Contingency Analysis

- Security is determined by the ability of the system to withstand equipment failure.
- Weak elements are those that present overloads in the contingency conditions (congestion).
- Standard approach is to perform a single (*N*-1) contingency analysis simulation; Limit B (long term emergency) ratings .
- A ranking method will be demonstrated to prioritize transmission planning.

Identification of Weak Elements

For California:

- Need to simulate all realistic contingencies (more than 6000 for California)
- Each contingency may result in several lines being overloaded (hot spots).

Results for California

- Simulation developed for 2003, 2005, 2007, 2010 and 2017 summer peak cases.
- In 2003, there were 170 violating contingencies, 255 contingency violations, and 146 weak elements.

Results: Contingency Summary

Year	Number of Contingencies	Violating Contingencies	Violations	Weak Elements
2003	6185	170	255	146
2005	6146	225	335	174
2007	6260	251	430	226

Results: Weak Element Distribution

Area		Number of Weak Elements		
Number	Name	2003	2005	2007
22	SANDIEGO	2	16	8
24	SOCALIF	30	33	34
26	LADWP	2	6	3
30	PG AND E	112	119	181
Total		**146**	**174**	**226**

CALIFORNIA ENERGY COMMISSION

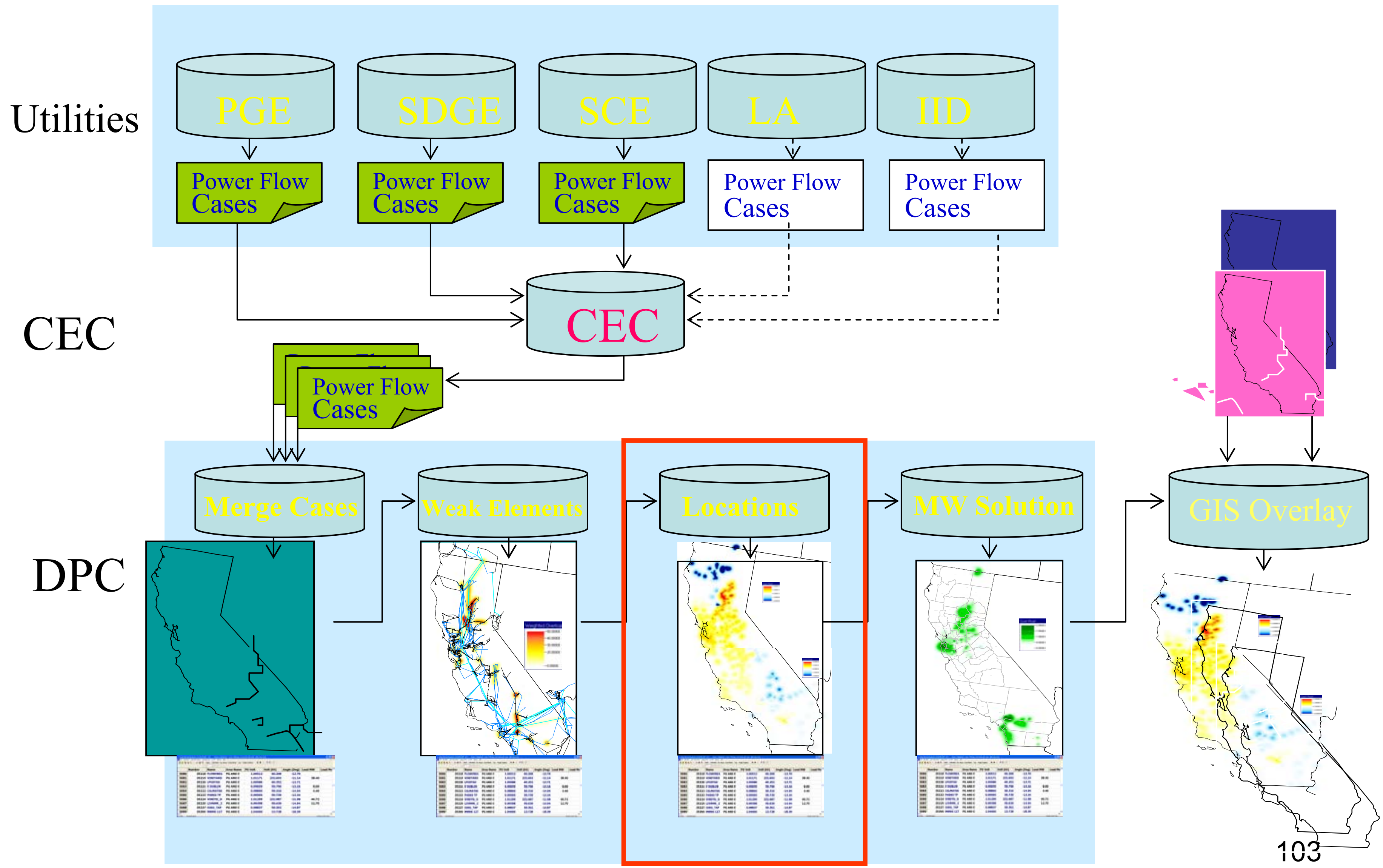
Renewable Transmission Planning Workshop

Determination of Beneficial Locations for New Generation

PUBLIC INTEREST ENERGY RESEARCH

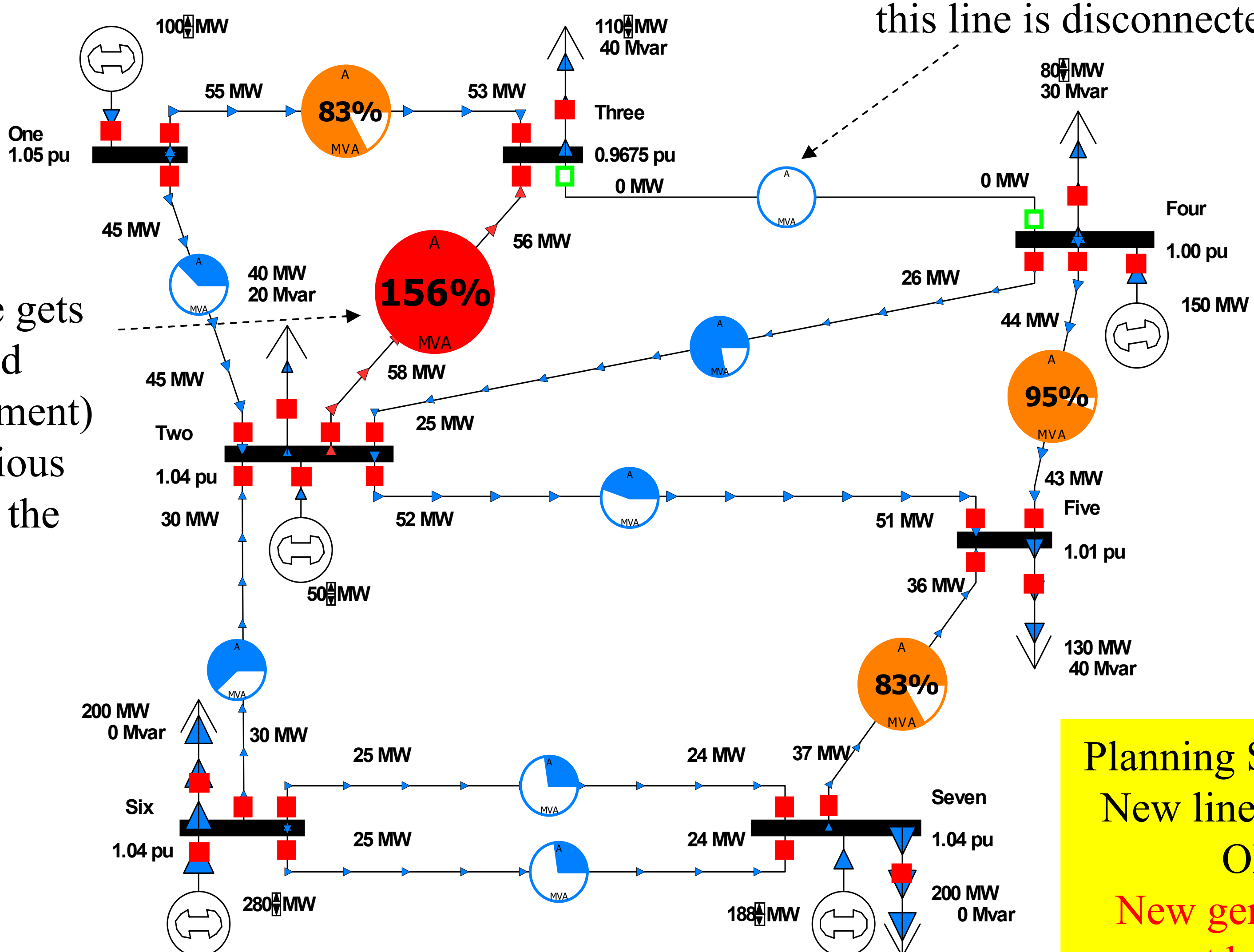
"Research Powers the Future"

Project Overview



Recall Contingency Example:

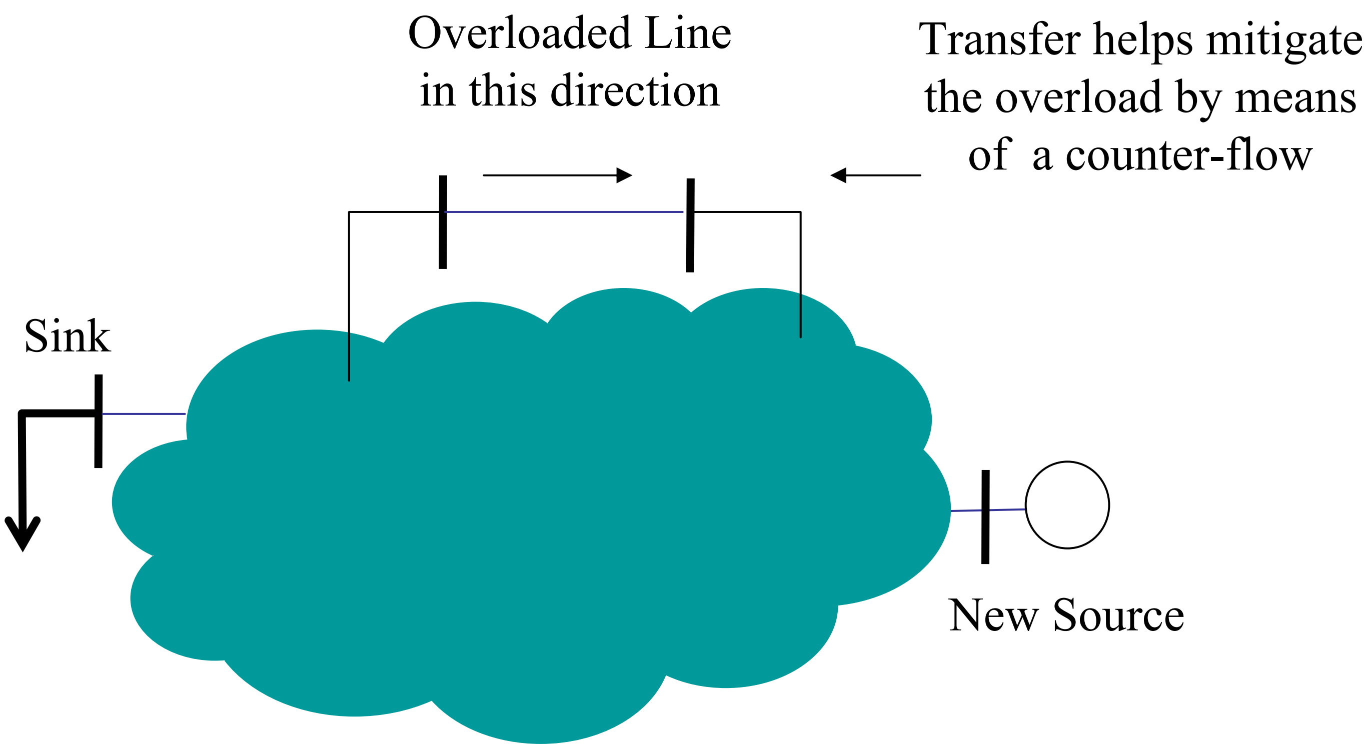
Suppose there is a fault and this line is disconnected



Then this line gets overloaded (is a weak element)
This is a serious problem for the system

Planning Solutions:
New line to bus 3
OR
New generation at bus 3

Main Strategy



Strategic Generation Siting

- Generation needs to be strategically located to produce counter-flows that mitigate weak elements contingency overloads.
- Overload mitigation results in:
  – Reduction of congestion.
  – Potential to avoid or delay need of transmission expansion

Strategic Generation Siting

- The new injection of power requires decreasing generation somewhere else.
- A good assumption is to assume that generation will be decreased across the system or each control area.

Definitions

- TLR – Transmission Loading Relief
  - How new injection at a certain bus will impact the flows on a transmission element.
  - Can determine where injections in the system could improve (reduce) flow on an overloaded element, and where injections could harm (increase) flow on an overloaded element.

Definitions

- AMWCO – Aggregated MW Contingency Overload
  - Sum of the overload flow on each element
    - Multiple contingencies may cause varying degrees of overload on a particular element
    - The amount of the overload (in %) above the element’s rating can be multiplied by the rating for each contingency causing a violation, giving the approximate MW amount above the limit on the element
    - The sum of these MW amounts for the element is the AMWCO of the element
  - Scaling the percentage overloads by the element’s limit addresses the issue of distinguishing between overloads on elements in different voltage levels

Definitions

- AMWCO (cont'd)
  - This can be used as an indicator of element strength
    - Elements with an AMWCO of 0 are not overloaded under any of the examined contingencies; they are secure
    - Elements with non-zero AMWCO exhibit security issues; the higher the value, the weaker the element
  - An AMWCO for a region (area, subsystem, entire system) can be calculated as the sum of all AMWCO values for elements within the region
    - Whether the AMWCO for a region is good or bad is a matter of policy; someone has to define the threshold for good vs. bad
    - AMWCO works well as a baseline for examining the affects on system security as the system continues to grow

Definitions

- WTLR – Weighted Transmission Loading Relief
  - Normalized sum of the Combination of AMWCO and TLR of each element in reference to each bus in the system
  - Provides a sensitivity (metric) of how much the system (or region) AMWCO can be improved with a 1 MW injection at each bus
    - Buses that have higher TLR values for branches with higher AMWCO values will have higher WTLR ratings; i.e. injection at the bus will have a greater potential for system improvement

Meaning of the WTLR

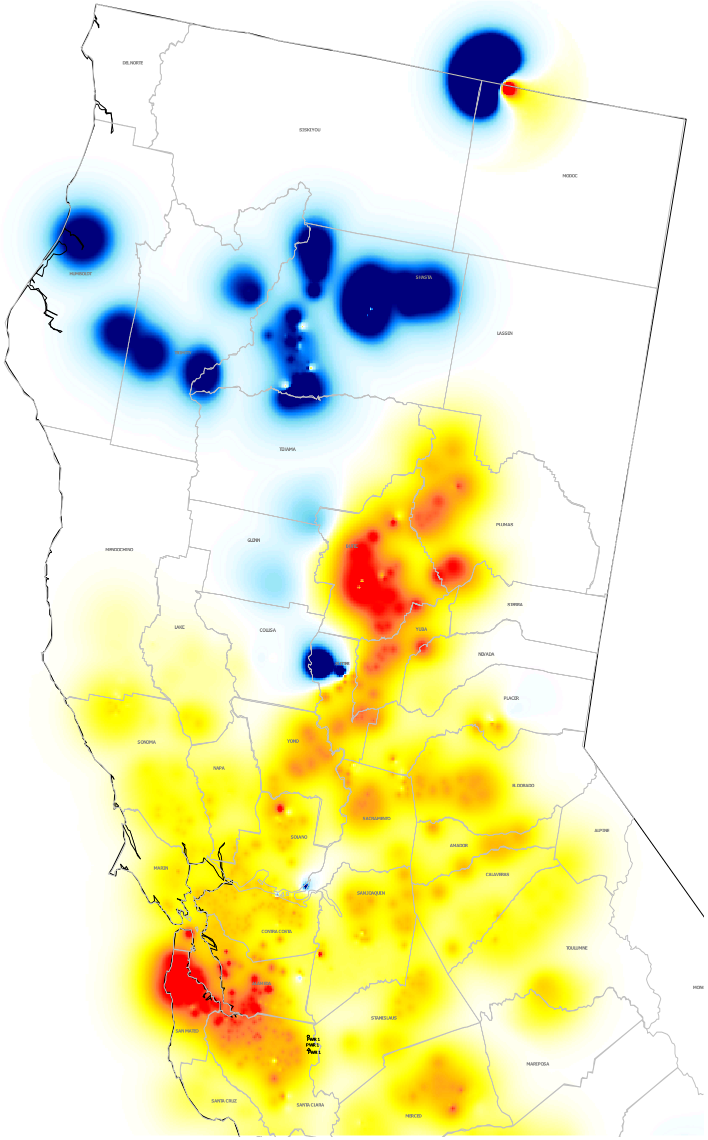
- A WTLR of 4.0 at a bus means that 1MW of new generation injected at the specific bus is likely to reduce 4.0 total MW of overload in weak transmission elements during contingencies.
- Thus, if we inject new generation at high impact buses, re-dispatch the system, and rerun the contingencies, the overloads will decrease.

Beneficial Locations

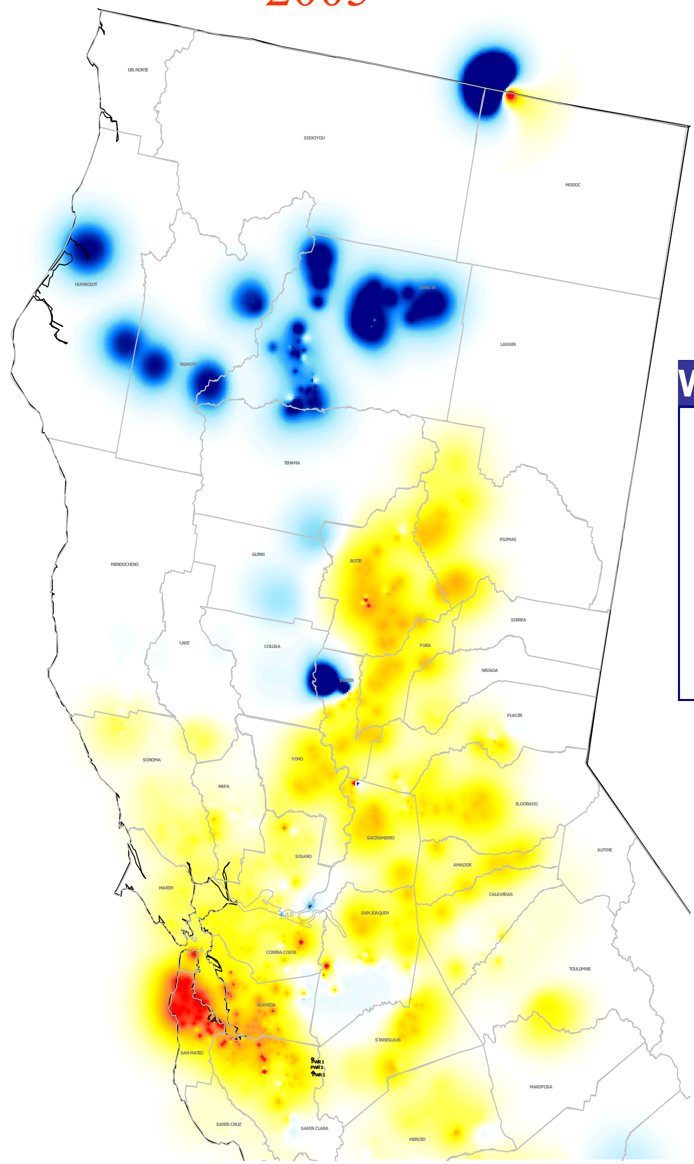
- New generation at the red-yellow locations will tend to reduce the overloads.
- New generation at blue locations will tend to increase the overloads.

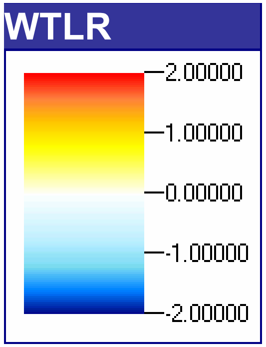
WTLR Visualization

2003

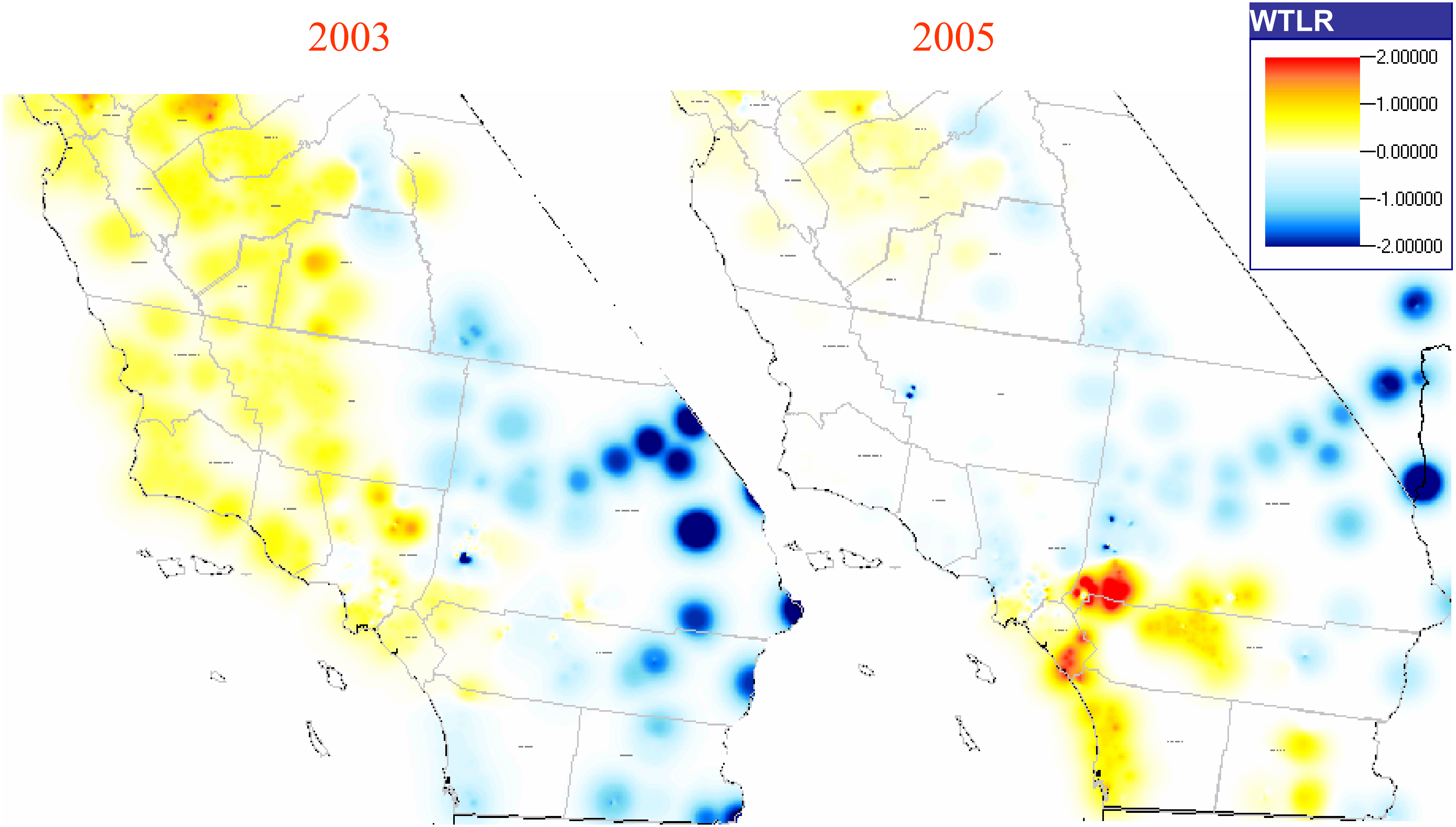


2005

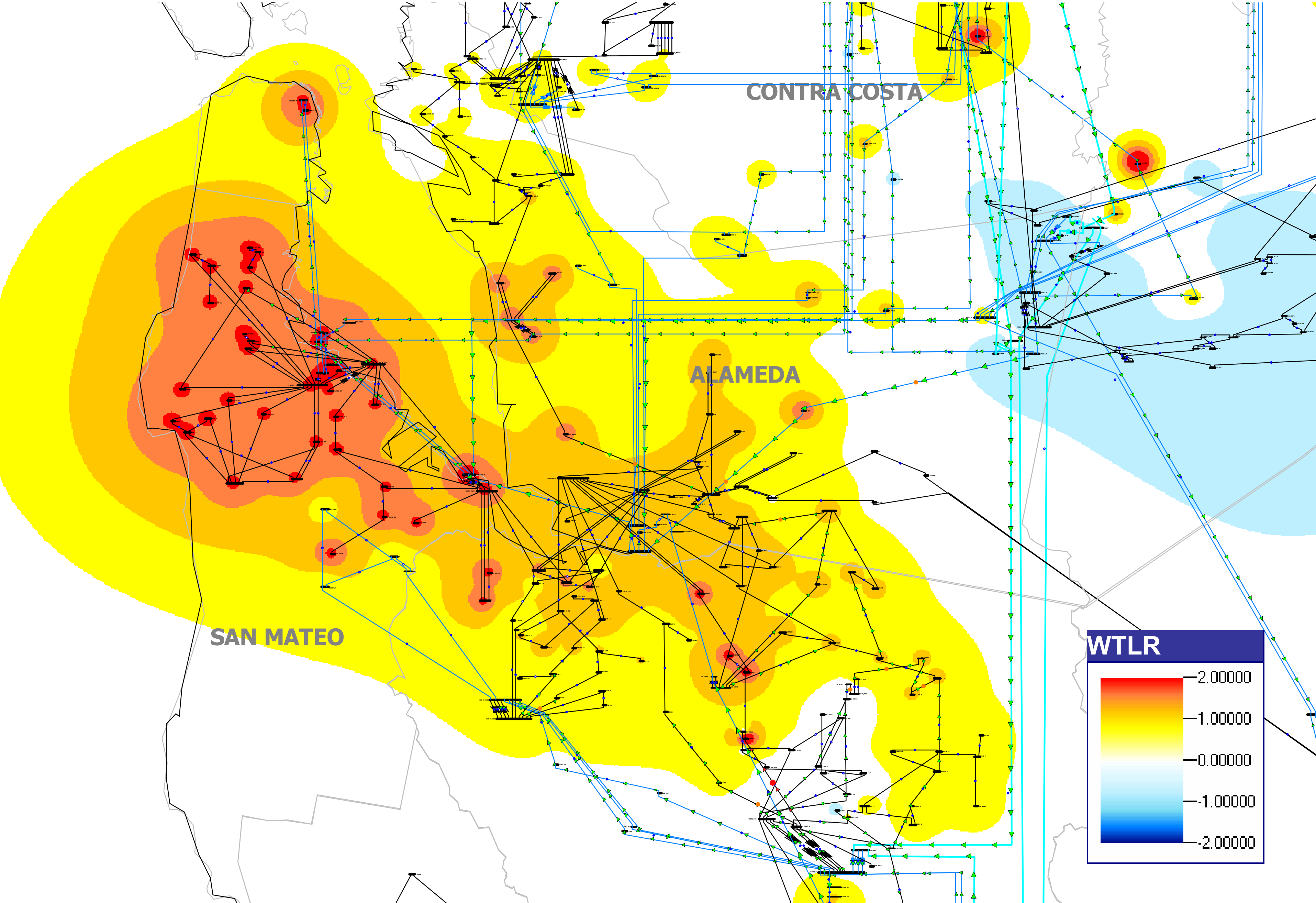




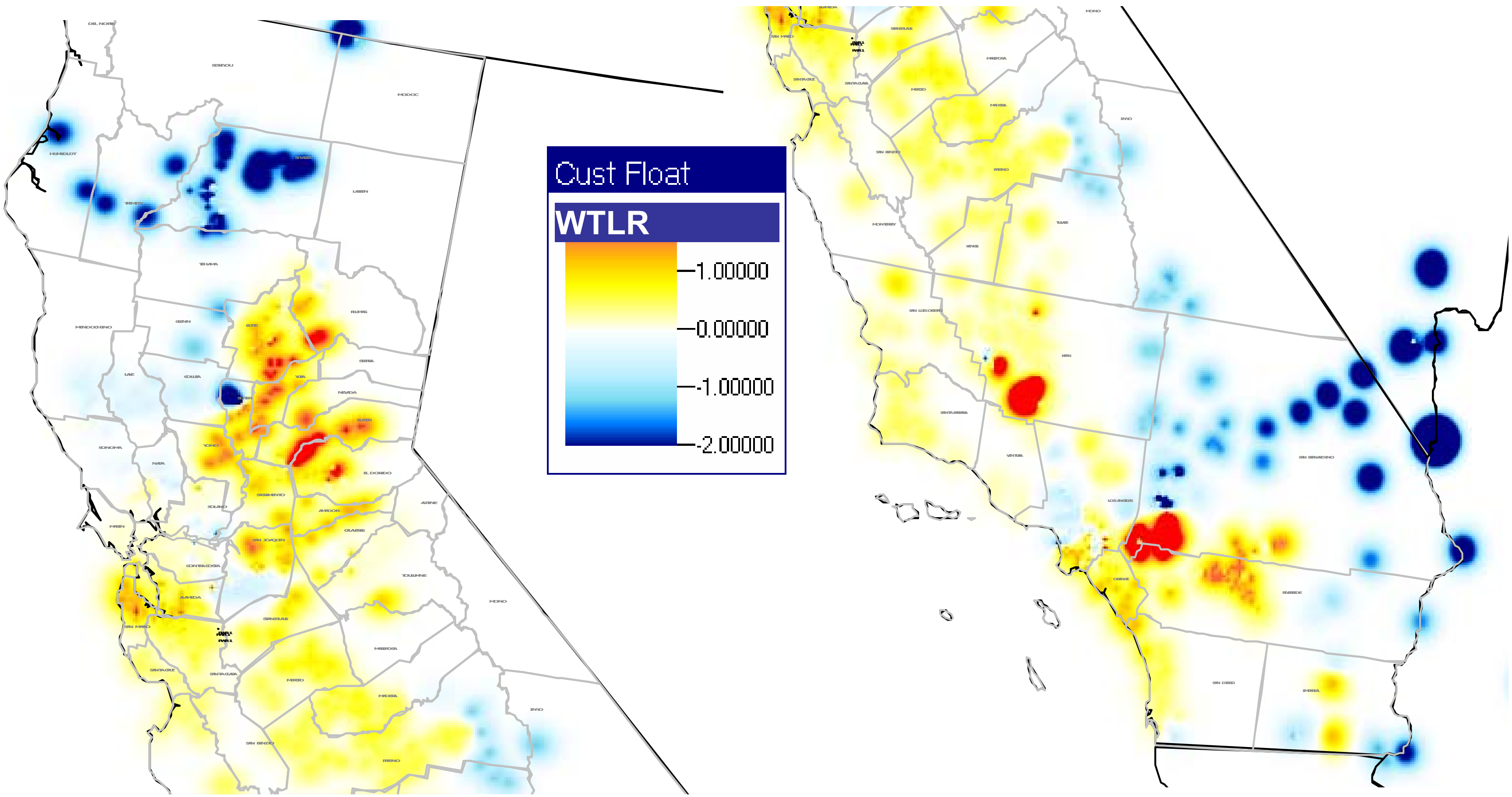
WTLR Visualization



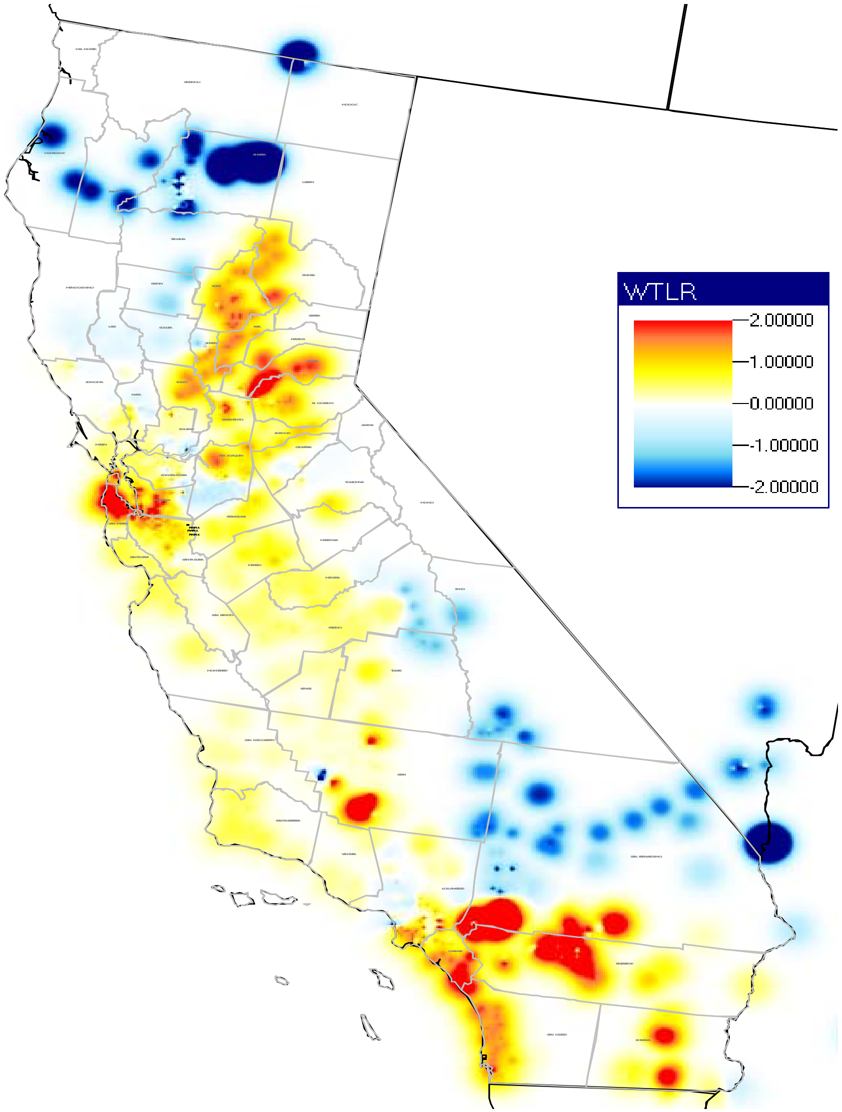
Detailed Visualization Example

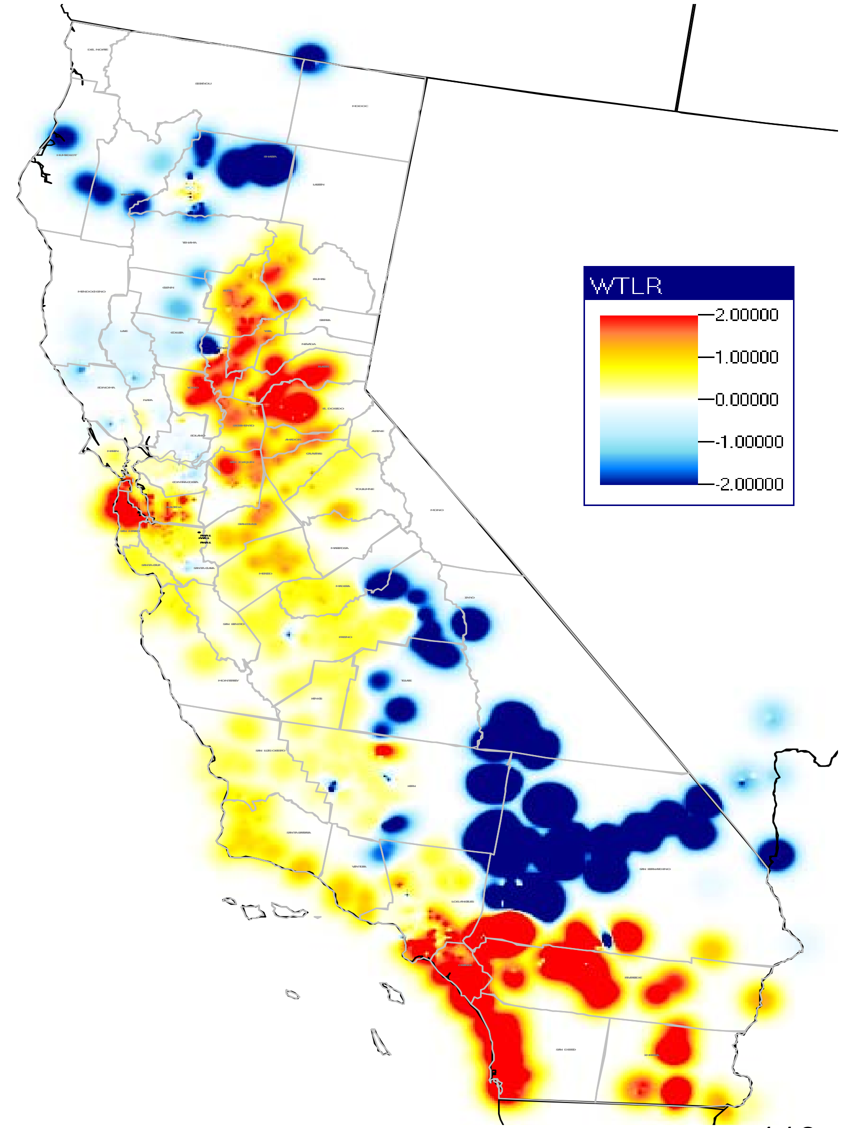


WTLR Visualization 2007



WTLR Visualization 2010-2017





Beneficial Location Patterns

- Since the weak elements have an identifiable spatial distribution from year to year, the beneficial locations have also a consistent spatial pattern.
- This means that:
  - The projected solutions do not affect significantly the spatial representation of beneficial locations
  - New solutions at beneficial locations implemented in 2005-07 will continue to be beneficial in 2010-2017.

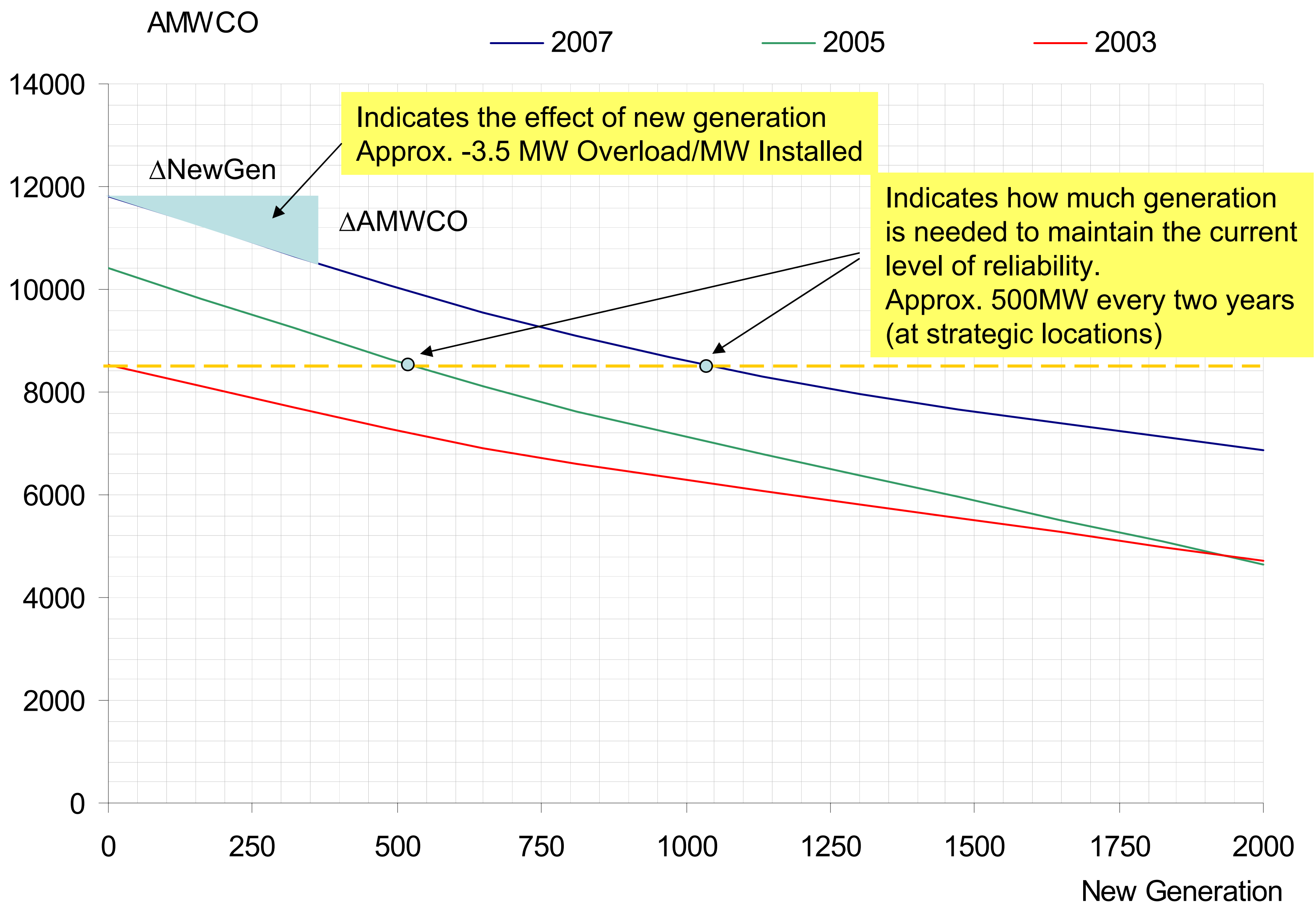
Results: System Reliability Indicator

Area		Aggregate MW Contingency Overload		
Number	Name	2003	2005	2007
22	SANDIEGO	10.54	607.14	107.56
24	SOCALIF	2,694.36	2,899.82	4,322.32
26	LADWP	133.77	193.75	497.48
30	PG AND E	5,713.75	6,839.55	8,948.78
System		**8,552.42**	**10,540.28**	**13,876.14**

Penetration-Reliability Curves

- Given a set of proposed projects for distributed generation, determine the reliability level versus different levels of penetration of new generation
  - Plot AMWCO versus new penetration level
- Each year is considered independently.

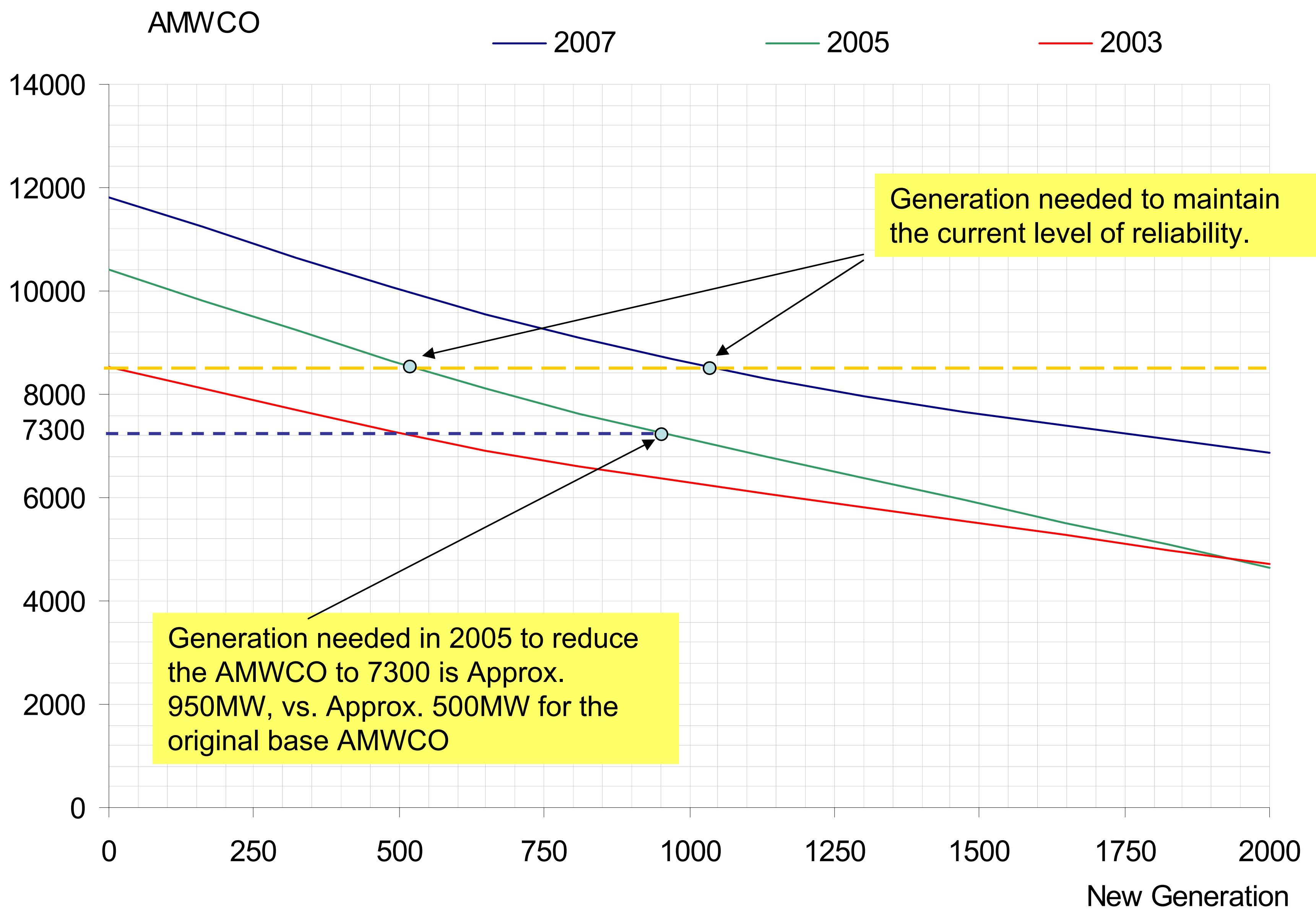
Penetration-Reliability Curves



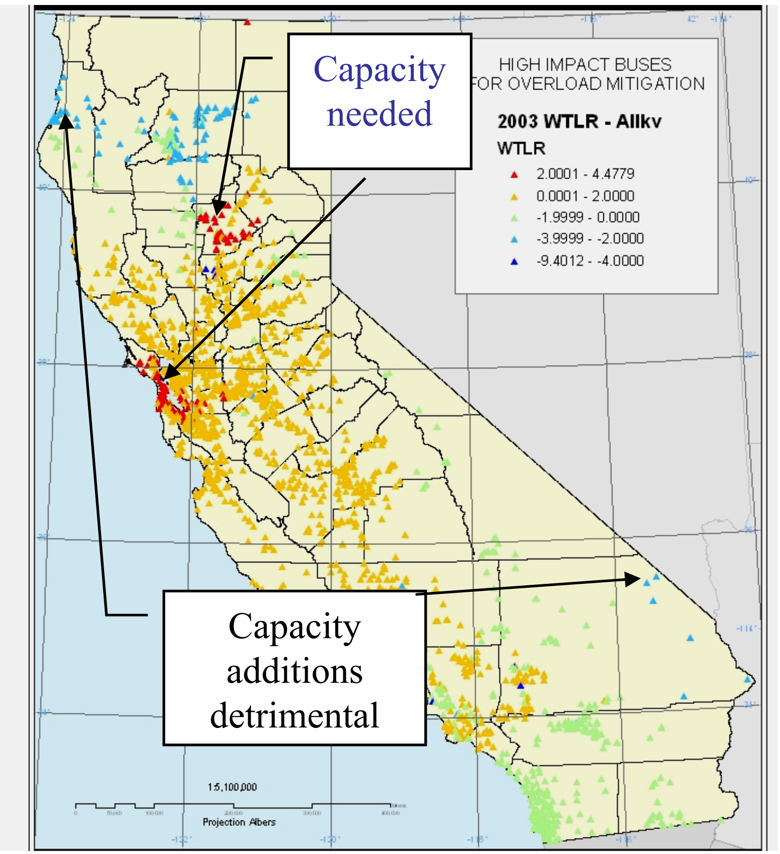
Penetration-Reliability Curves

- Can be used to determine the required level of penetration to achieve a certain reliability target.
- For instance, what if the target AMWCO is less than the current base AMWCO of 8,552? Say for 2005, the AMWCO is desired to be 7,300. Approximately how much generation should be installed?

Penetration-Reliability Curves



Electricity System: 2003

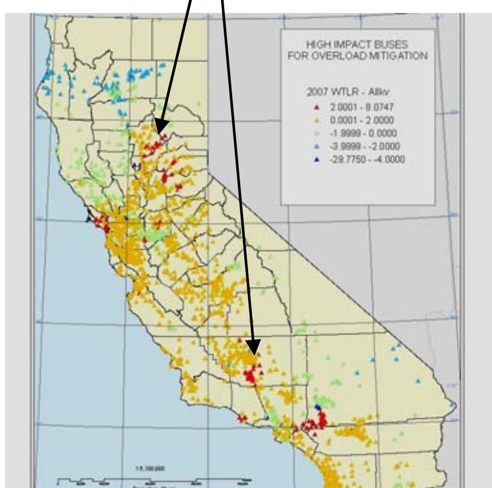


- "Calibrates" model
  - Identifies potential "hot spots" in system via branch overloading
  - Weighted Transmission Loading Relief (WTLRs) identified via buses
    - Identifies where to add capacity
      - Red: capacity needed & provides system benefit
      - Yellow: capacity needed, but smaller system benefit
      - Blue: capacity additions are detrimental
- Results:
  - 170 contingencies that cause security limit violations
  - 255 violations aggregated in 146 "hot spots"
  - Overall security indicator equivalent to potential 8552 MW overload
  - Mostly located in PG&E (2/3rd) and SCE (1/3rd) territories

Electricity System: 2005 - 2007

2005 System

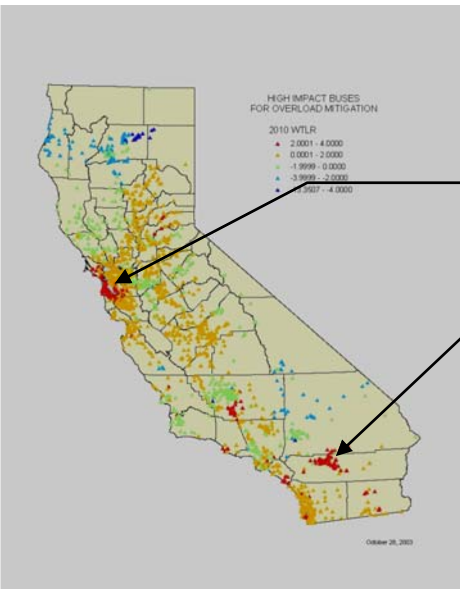
Expanding need for capacity additions



2007 System

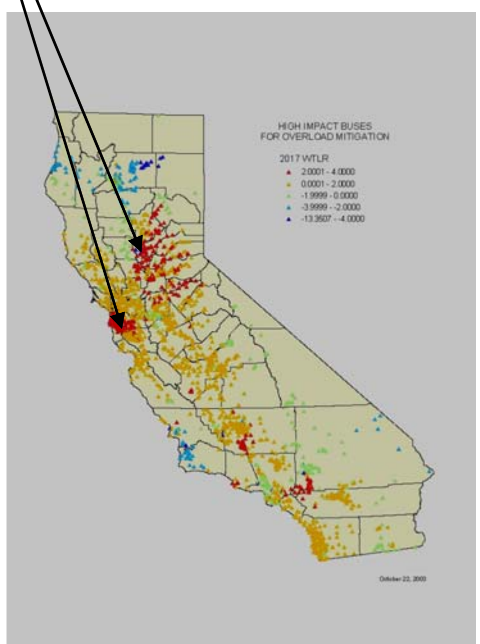
- Assumptions:
  - Summer peak scenario
  - Demand for 2007 extrapolated from 2003 & 2005 demand levels
  - New generation units in 2005 and 2007 based on CEC demand data and new generation facilities input
    - Electricity Analysis Office
    - Transmission Group
- Results:
  - Continued growth in possible overloads
    - 2005: 225 contingencies with 10,540 MW overload potential
    - 2007: 251 contingencies with 13,876 MW overload potential

Electricity System: 2010 & 2017



2010 System

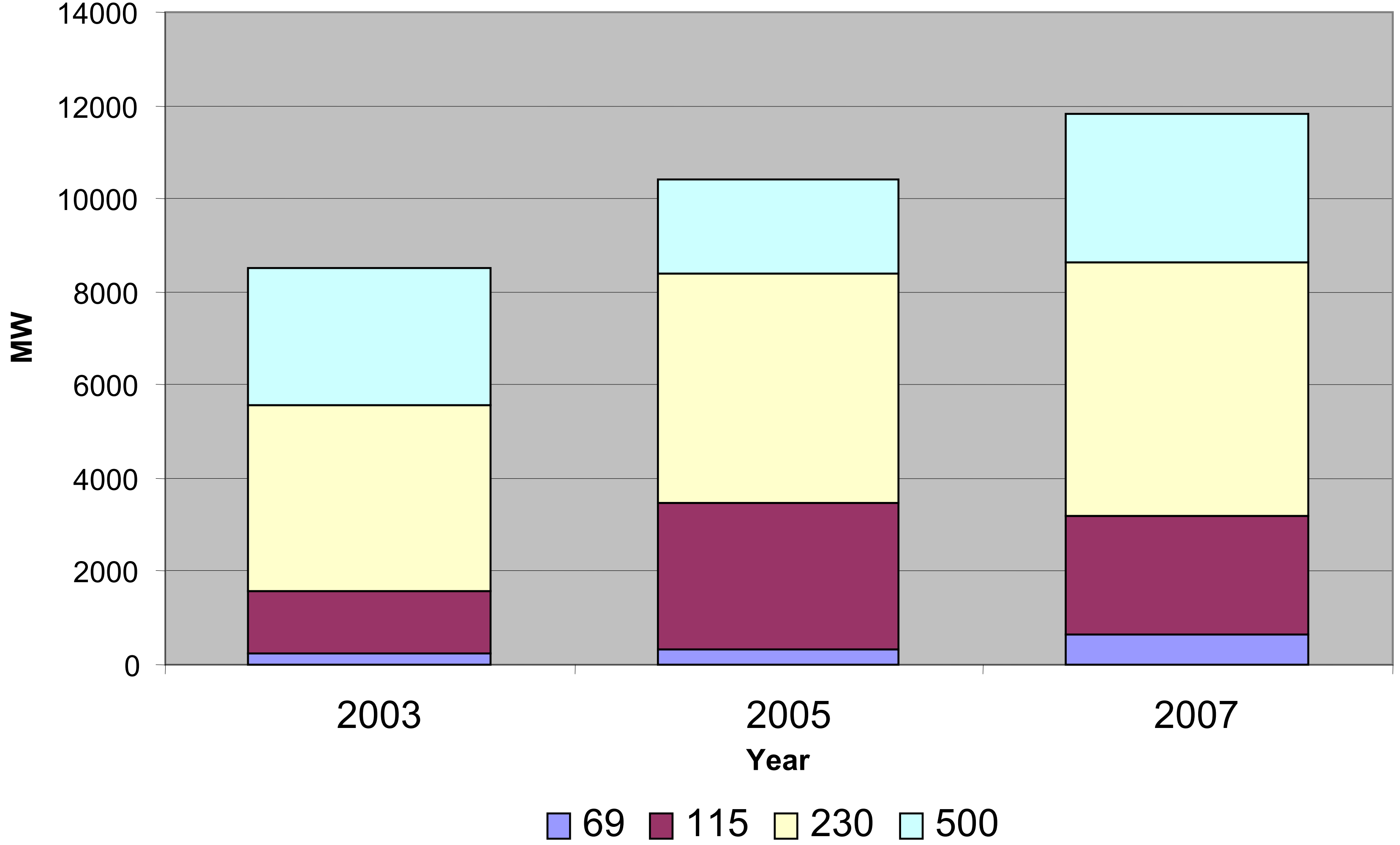
Increasing severity & numbers of reliability problems



2017 System

- Assumptions:
  - Summer peak scenario
  - Demand for 2010 and 2017 extrapolated from 2007 demand levels
  - New generation units in 2010 and 2017 based on CEC input on new generation and transmission
- Results:
  - Continued growth in possible overloads
    - 2010: 409 contingencies with 17,256 MW overload potential
    - 2017: 674 contingencies with 30,657 MW overload potential

AMWCO by Voltage Level



Why a Unique Criteria?

- Avoids the battle of the models
- Allows for comparisons of alternatives on a common format
- Evaluates the overall reliability of the system using a contingency based technique
- Allows the user to evaluate benefits of different voltage based solutions on common format

Conclusions

Overall Conclusions

- Objective is not to dictate renewable technology development or locations to utilities and developers
- Rather the objective is to provide a common format for comparing the economics, public benefits and transmission reliability improvements between renewable technologies and conventional solutions

Overall Cont'd

- Since there are numerous locations available for renewable development, this methodology enables users to compare alternatives on a common playing field
- Naming conventions were difficult: WECC one standard; Commission mapping office had another method; and Electricity Analysis Office had a third.
- Difficult in getting 100 % match for GIS mapping
- Need to interface and work closer with the Electricity Analysis Office on data set development

Conclusion Cont’d

- Tools are powerful, accurate, portable, flexible and easy to use
- Locations found that provide transmission reliability improvement while supporting renewable technology development
- Analysis works equally well for evaluating new transmission and conventional generating projects
- Allows for a common basis for evaluating various technology types and development
- Provides a common forum for Commissions, utilities and developers to determine the location and timing of new generating/transmission projects

Project Diversification

- Can be used to compare the transmission reliability value and economic value between
  - Distributed generation
  - Central station renewable resources
  - Transmission upgrades or new lines
  - Conventional generation resources (gas)
- Provides a common format for comparing resource alternatives

Next Steps

- Match utility resource needs and generating type (base, intermediate, peaking) with renewable technology alternatives
- Transmission power flows only look at a snapshot
- Need to incorporate power simulation modeling to determine proper mix
- Interaction between Commission, utilities and developers ensures proper and timely development